Offsite Remedial Investigation Final Report Vol. I (Report\Bibliography) 12/1/85

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OFFSITE
REMEDIAL INVESTIGATION
VERTAC, Inc., Jacksonville, AR
FINAL REPORT
VOLUME I

REPORT & BIBLIOGRAPHY

Project No. CH313-6
Site No. 88-6L04.0
TDD No. R06-8404-01

December 1, 1985

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ACKNOWLEDGEMENTS

Many Federal, State, and Local agencies and private companies were contacted to find and secure available information and data. Their assistance is hereby acknowledged.

Federal Agencies

- U.S. Geological Survey, Little Rock District, Little Rock, Arkansas
- U.S.D.A. Soil Conservation Service, Little Rock, Arkansas
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EXECUTIVE SUMMARY

The Remedial Investigation (RI) of the offsite area adjacent to the Vertac Chemical Corporation plant, Jacksonville, Arkansas (see Site Location Map, Map 1-1; and Investigation Area Map, Map 1-2), was performed between the fall of 1983 and spring of 1985. The purpose of the RI was to discover if dioxin (2,3,7,8-TCDD in the case of soil and sediment samples; other forms of TCDD, as in the biota analysis, are specified) had migrated off the plant site, and if so, to identify contaminated areas.

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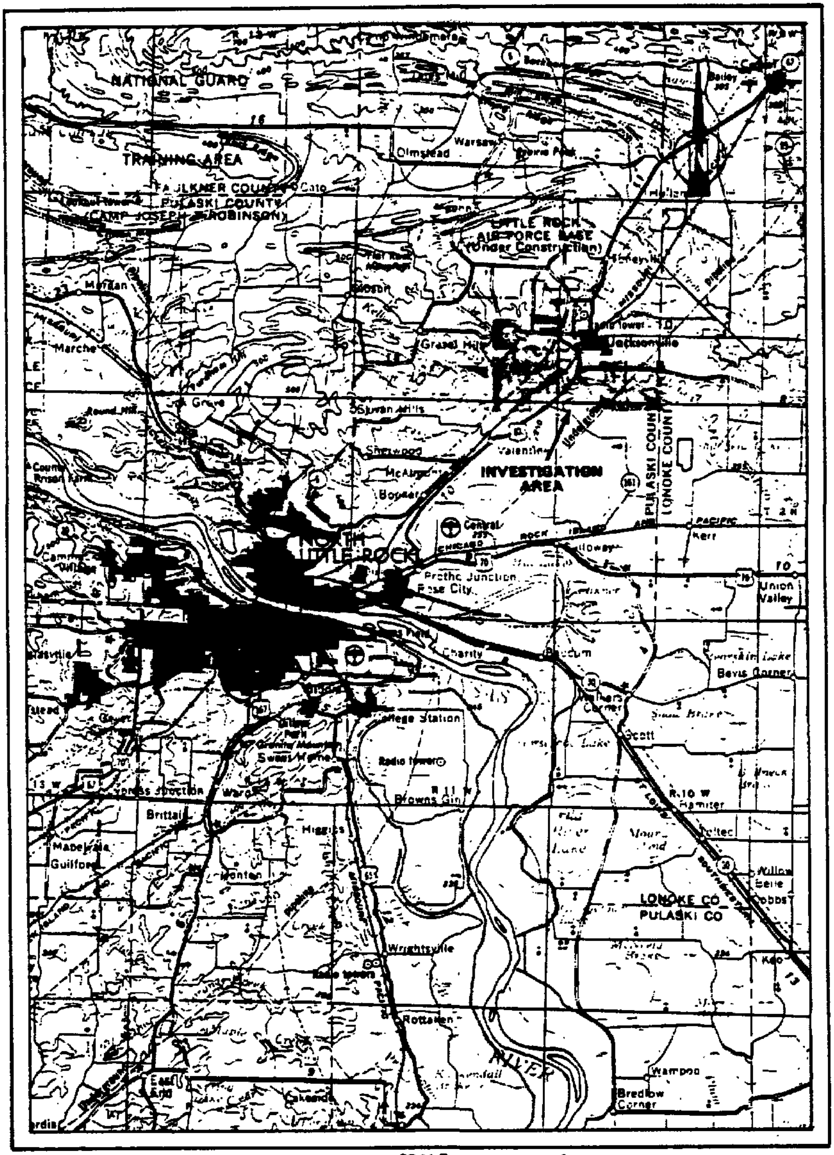
Pesticides including 2,4,5-T, of which dioxin is a by-product, 2,4-D, and 2,4,5-TP have been produced at the Vertac site over the years. Attention was first focused on the plant as a possible source of dioxin contamination after the National Dioxin Survey of 1978. Dioxin was found in fish and wildlife as far as 50 miles downstream of the plant.

The plant area is drained by Rocky Branch, a small watercourse that flows into Bayou Meto, a larger watercourse that flows into the Arkansas River. The plant and adjacent residential areas are also served by the Jacksonville combined sanitary and storm sewer system, which empties into Bayou Meto. Moreover, Rocky Branch and Bayou Meto flood frequently, which would carry any contaminants in the stream waters onto the floodplain and into several water impoundments in the floodplain. Bayou Meto waters are also used for irrigation of nearby farmlands.

The results of previous studies suggested that contamination in the investigation area would be concentrated in the sewage collection and treatment system and along the watercourses. Dioxin is known to have an extremely low water solubility and a strong tendency to bind to soils or sediments. Therefore, fieldwork for the RI consisted of soil and sediment sampling and analysis on three occasions, as well as a series of special investigations, including: a floodplain delineation study to assist in estimating the amount of soil that could be



SCALE

0 5 10 MILES

0 5 10 KILOMETERS

MAP 1—1 SITE LOCATION MAP

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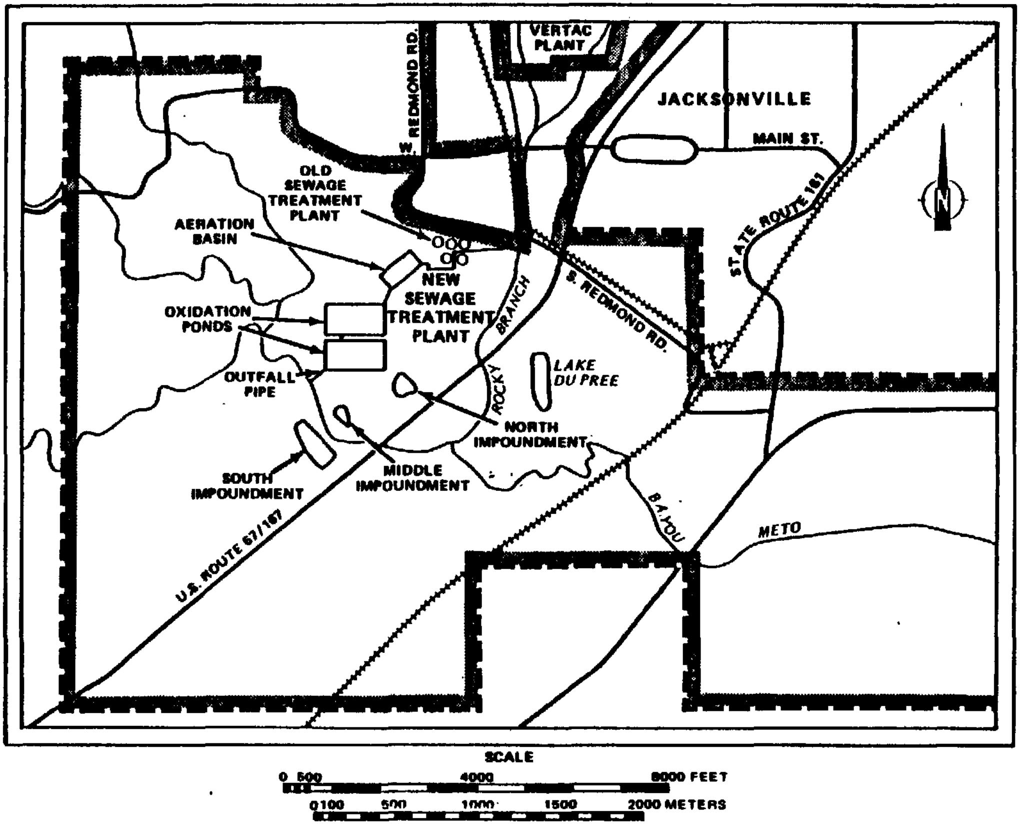

MAP 1–2 INVESTIGATION AREA MAP

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contaminated as a result of floods; a sewer lamping to assist in estimating the amount of sediment in the sewage collection and treatment systems; a sonar survey to assist in calculating the amount of sediment in the impoundments; and an aquatic biota survey.

Groundwater sampling and analysis was not included in the study plan based on the low water solubility of dioxin as well as a limited testing of deep wells in the early stages of the RI which showed no measurable dioxin in groundwater. Surface water was not tested because of the low water solubility of dioxin. Concentration on soils and sediments was considered a more effective use of RI funds.

Air was considered as a potential pathway of contaminant migration. However, the area is heavily vegetated, minimizing airborne transport of soil and sediment. Air monitoring was not pursued because it was considered a relatively less effective use of RI funds.

Previous study results had indicated contaminants other than dioxin in the investigation area, such as 2,4-D, 2,4,5-T, 2,4,5-TP, chlorinated benzenes, and chlorinated phenols. The RI concentrated on dioxin, however, since it is considered the most hazardous contaminant in the area and remediation for dioxin would also remediate most other contamination problems in the area. Limited, exploratory testing was performed for the other compounds, but the results were inadequate to precisely determine the extent and amount of such contamination. Elevated levels of chlorobenzenes, chlorophenols, and other contaminants were found, principally in the sewage system, to a much lesser degree at surface locations near the Vertac plant, and sporadically at locations distant from the plant. The findings on these other contaminants appear consistent with known differences in persistency between these substances and dioxin. These contaminants degrade more readily than dioxin. In the areas where other contaminants than dioxin were found, dioxin was also found at concentrations of greater concern than the concentrations of the other contaminants. Thus, remediation for dioxin would also remediate the other contamination.

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Based on the previous study results, the soils and sediment sampling program outlined in the study plan was considered adequate to determine the extent and amount of contaminated materials in the investigation area. A standard lower quantification limit for dioxins 1 ppb was mandated for the laboratory analyses. In many cases, however, the laboratories tested for lower concentrations.

A total of 324 soil and sediment samples were collected during the RI and tested for dioxin. Seventy four were taken in December 1983, of which 40 contained measured quantities of dioxin; 21 were taken in June 1984, of which 1 contained a measured quantity; and 225 were taken in August 1984, of which 79 contained measured quantities.

In Rocky Branch, concentrations in excess of 2 ppb were found in samples upstream of W. Main Street and at Highway 67/167. Dioxin concentrations were found to decrease with distance from the Vertac plant site.

In Bayou Meto, a wide range of concentrations was found. The most notable findings were the sharp rise in concentrations below the Sewage Treatment Plant outfall into the bayou, and the slight effect of Rocky Branch entering the bayou. Only a slight increase was found in samples downstream versus upstream of the mouth. It appears that most contamination is trapped in sediment between the Sewage Treatment Plant outfall and Highway 161.

No samples from Lake DuPree or the north, middle, or south unnamed impoundments showed dioxin concentrations as high as 1 ppb.

In the floodplain, the data indicate possible low-level contamination. While some contaminated deposit areas were located, considering the vast expanse of the floodplain and the small number of samples collected, the existence of other deposit areas remains a possibility. However, the data indicate that the majority of the floodplain has only low concentrations of dioxin, if any.

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All components of the sewage collection and treatment system, including the old and new sewage treatment systems, appear to be contaminated with dioxin. The new sewage treatment plant is also known as the West Plant. The average dioxin concentration of 26 samples in the sewage collection system, excluding the three highest samples, was 7.93 ppb. Including the three highest, it was 21.5 ppb. The highest concentration was greater than 200 ppb. Dioxin concentrations in the aeration basin averaged 15.7 ppb. In the north oxidation pond, the average of samples containing more than 1 ppb was 3.65 ppb. In the south oxidation pond, it was 4.01 ppb.

The total estimated volume of sediment in the New Sewage Treatment Plant aeration basin and oxidation ponds is 214,000 cubic yards. The total estimated volume in the Old Sewage Treatment Plant facilities is 500 cu yd. The total estimated volume in the sewage collection system is 47 cu yd.

The RI was successfully completed according to the intent of the study plan. However, the sewer lamping performed as part of the RI showed deteriorated and broken sewer lines and indicated the possibility of exfiltration of contaminants into the shallow groundwater adjacent to the sewer lines during low water table conditions associated with extended dry periods during summer and early fall. Furthermore, along the watercourses and in the floodplain, most sample results were below the mandated lower quantification limit of 1 ppb, including many measured concentrations. To better define the extent and amount of contamination in the groundwater and along the watercourses and in the floodplain, local groundwater conditions would have to be defined along the sewer lines, and samples would have to be taken at new locations and tested to quantification limits less than 1 ppb.

The RI data also indicated a correlation of dioxin distribution and scour and deposition activity in the floodplain. To more effectively locate scour and deposit areas, fine-grid sampling or computer modeling of the floodplain would be necessary. Two possible computer models are outlined in Appendix 8.

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1. INTRODUCTION

This is a report on the Remedial Investigation (RI) of the offsite area adjacent to the Vertac Chemical Corporation (Vertac) pesticide plant, Jacksonville, Arkansas. Jacksonville is about 14 miles northeast of Little Rock (see Site Location map, Map 1-1; and Investigation Area map, Map 1-2). The purpose of the RI was to determine if contaminants have migrated from Vertac to offsite areas, and if so, to identify contaminated areas. A further purpose was to provide data for the subsequent Feasibility Study which is to develop remedial action alternatives.

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The RI scope was outlined in a Remedial Action Master Plan and Work Plan. Initial efforts were directed toward three major tasks:

- Gathering and reviewing Jacksonville sewage treatment facilities data;
- Preparing a fish sampling plan; and
- Collecting available data and conducting field reconnaissance to assist in preparation of a comprehensive soil and sediment sampling plan.

The third task included development of the sampling plan for the Jacksonville sewage collection and treatment system, Rocky Branch, Bayou Meto, and floodplain suspect of containing contaminated soils and sediments. In order to facilitate floodplain sampling, the USGS performed a floodplain delineation study (see Section 4.1). Also, as part of the third task, an exploratory sampling of the floodplain south of Bayou Meto was performed in June 1984.

A comprehensive sampling plan, including a report on accomplishment of all tasks, was completed in July 1984, and was approved in August 1984. On the basis of this plan, a comprehensive soil and sediment sampling was performed between August 13 and 30, 1984.

In accordance with the foregoing, the scope of the Work Plan was revised, containing the following tasks:

- Developing a history and description of the offsite area, including collection of available data;
- Performing a series of special investigations;
- Sampling and analysis of soils and sediment;
- Sampling and analysis of aquatic biota;
- Evaluation of the analytical data to determine if contaminants have migrated offsite;
- Delineation of contaminated areas; and
- Estimating volumes of contaminated soils and sediments.

The pesticide plant is on the site of a former World War II ordnance plant. Pesticides were produced there since 1948. Dioxin (2,3,7,8-tetrachlorodibenzodioxin) was produced as a by-product of 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid] since before 1961. Attention was focused on the plant as a possible source of dioxin contamination after the National Dioxin Survey of 1978. Investigations showed dioxin in wastes on site and in fish and wildlife as far as 50 miles from the plant (2,3,7,8-TCDD in the case of soil and sediment samples; other forms of TCDD--as in the biota analysis--are specified).

The plant area is drained by a watercourse called Rocky Branch, which flows into a larger watercourse called Bayou Meto, which in turn flows into the Arkansas River. Wastes from the plant have been conveyed to the Jacksonville Sewage Treatment Plant through the city sewage collection lines, and from the treatment plant to Bayou Meto.

Rocky Branch and Bayou Meto frequently flood. So any contaminants in their waters could be deposited on the surrounding land and in nearby water impoundments via floodwaters. Furthermore, Bayou Meto is used for irrigation of surrounding farm fields, which would also spread contaminants in the water onto the land.

Special investigations for the RI included: a floodplain delineation study; a sonar survey of the impoundments to assist estimating quantities of sediments; a water use inventory; a sewer lamping to determine the condition of sewer lines and manholes in the sewage collection

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system; a groundwater study; an investigation of some drums that were found during field work; and an aquatic biota study.

Dioxin is known to have an extremely low water solubility and a strong tendency to adhere to soil or sediment particles, and so the main effort of the RI was soil and sediment sampling and analysis. Soil and sediment samples were taken on three occasions. In December 1983, 74 samples were taken near the Vertac plant, along the watercourses, in three lakes, in the sewage treatment plant, and in sewer lines. In June 1984, 21 samples were taken south of Bayou Meto. Finally, in August 1984, 225 samples were taken, including samples from various depths at individual locations throughout the investigation area. Analyses of the samples were performed by various laboratories of the EPA Contract Laboratories Program (CLP). The samples were analyzed for dioxin to a CLP-mandated lower quantification limit of 1 ppb, although many samples were analyzed to lower limits, including measured concentrations. Selection of 1 ppb represents economy of analysis. It is not to be construed as an "action level," "health effects level," or state-of-the-art limitation of analytical capabilities. The data were evaluated and estimates were made of volumes of contaminated materials.

Limited testing was performed during and previous to the RI for chemicals other than dioxin that were suspected contaminants (2,4-D [(2,4-dichlorophenoxy)acetic acid]; 2,4,5-TP [2-(2,4,5-trichlorophenoxy) propionic acid]; 2,4,5-T; toluene; chlorinated benzenes; and chlorinated phenols). But the primary purpose of obtaining data on these chemicals was exploratory, rather than to determine the amount or extent of contamination, or estimate quantities of contaminated material.

Groundwater was also considered. However, it was not sampled in December 1983, June 1984, or August 1984 because sampling of three deep wells in the early stage of the investigation indicated that the water "did not contain, at detectable limits, any of the contaminants that may have been released from the Vertac site" (Draft Summary Report 1984). No shallow groundwater monitoring wells exist offsite.

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Moreover, since dioxin has a low water solubility, it is less likely to be found in water than other media.

Similarly, because of the low water solubility of dioxin, surface water was not tested. It was considered a more effective use of investigation funds to concentrate on soils and sediments.

In addition to the special investigations and sampling and analysis, the RI work included a flyover of the investigation area and the examination and comparison of aerial photos from the past and present. A visual stream survey was made as part of the floodplain analysis and to assist in the selection of sampling locations.

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2. HISTORY

Information presented below was obtained from various sources listed in the bibliography. The more important sources were: Summary of Technical Data 1983; CH2M Hill/Ecology and Environment 1984; City of Jacksonville 1971; Cochran 1983; and Ecology and Environment, August 1984.

2.1 PLANT SITE

The Vertac plant site was the location of the Arkansas Ordnance Plant during World War II. The ordnance plant was purchased in 1948 by the Reasor-Hill Company, which began to manufacture pesticides at the site, including 2,4,5-T. A by-product of 2,4,5-T production was dioxin.

In 1961, Reasor-Hill sold the plant to Hercules Powder Company (later Hercules, Inc.), which continued pesticide production until 1971. The manufacturing during this period involved pesticides and phenoxy herbicides. In particular, Hercules produced large quantities of Agent Orange, which is a mixture of 2,4,5-T and 2,4-D. Hercules also produced, as separate products: 2,4,5-T; 2,4-D; and 2,4,5-TP.

In 1963, Hercules instituted an extraction process which removed most of the dioxins from its products. The process produced solid and liquid wastes contaminated with dioxin. For many years, the liquid wastes were channeled through an equalization basin whose primary purpose was sedimentation and some degree of pH equalization. At the outflow end, the pH was adjusted to near-neutral levels prior to discharge via an outfall line into the sewage treatment system. The solid wastes were buried onsite, mainly in two landfill areas, a south area and a north area.

A noncontact cooling water pond was constructed on the west leg of Rocky Branch on the plant property. Although the cooling water pond was to receive only uncontaminated water, its sediments became

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contaminated. The likely sources of contamination were surface runoff from the area around the process facilities and the formerly open north landfill area, leachate from the buried wastes, and a main surface drainageway on the property.

From 1971 to 1976, Transvaal leased the site from Hercules. In 1976, Transvaal was reorganized into Vertac, Inc., which still operates the plant. Throughout the Transvaal-Vertac period, the plant has continued to manufacture 2,4,5-T; 2,4-D; and 2,4,5-TP. In March 1979, Vertac suspended production of these substances. However, production of 2,4-D was later resumed.

Attention was first focused on the Vertac plant after the National Dioxin Survey in 1978. EPA sampled production wastes at the facility and concentrations as high as 40 ppm of dioxin were found in the waste sludges. Lower concentrations were found in materials relating to other steps of the process. As a result of these findings, Region 6 EPA and the Arkansas Department of Pollution Control and Ecology (ADPC&E) began investigation. The state investigation showed dioxin contamination in wildlife and fish as far as 50 miles downstream from the plant. Samples of the leachate were found to contain dioxin, various pesticides (particularly 2,4,5-T and 2,4-D) and trichlorophenols. High levels of dioxin contamination were found in the sediments of the equalization basin. In addition, the noncontact cooling water was found to be contaminated with phenols, chlorobenzenes, and phenoxy herbicides, and dioxin was found in the cooling pond sediments.

Pursuant to a 1980 Consent Decree, thousands of drums were recontainerized and placed in storage; a clay barrier wall and a French drain were constructed at the south burial site; both the south and the north burial sites were covered and capped; the equalization basin was drained, its sediments were solidified, and the basin was filled and capped. Detailed chronology of the remedial actions taken by Vertac is contained in the "Summary of Technical Data" (ADPC&E 1983).

In an onsite inventory in February 1982, 2,747 drums of 2,4,5-T and 9,472 drums of 2,4-D still bottom material (bottom accumulation from

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the manufacturing process) were counted. At the present time, the 2,4-D inventory exceeds 22,000 drums, and is growing at a rate of approximately 300 drums per month. In July 1982, Vertac began a process to recover 2,4-D waste. However, waste recovery has been discontinued and Vertac is currently considering disposing of the waste by incineration.

EPA did not feel that the remedy being implemented at the site provided adequate protection for human health and the environment. When negotiations failed to resolve differences between EPA and Vertac, Vertac asked for court intervention. In the summer of 1984, the court ruled in Vertac's favor. To prevent migration of buried wastes at the plant, the court decision mandated construction of slurry walls and French Drain systems, extending existing clay caps, and upgrading protective vegetation at the burial sites, drainage of the cooling water pond, and removal of its contaminated sediments. Excess rainfall during October 1984 and underestimating quantities of sediment in the cooling pond prevented completion of work. Present plans call for completion of onsite remedial work at the plant by November 1985.

2.2 OFFSITE INVESTIGATION AREA

It is likely that escape of contaminants to offsite areas dates back to 1948, when the first pesticide production started, and became more substantial after the beginning of production of Agent Orange in the 1960s.

The Arkansas Ordnance Plant sewer lines had been constructed in 1941 and were in operation at the time Reasor-Hill purchased the plant. It is likely that during the Reasor-Hill period, pesticide-laden wastes were continually discharged into the sewer lines and into Rocky Branch.

The Old Sewage Treatment Plant was in operation until 1961. Although arrangements to treat wastes from the pesticide operation were only

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formalized in 1961, problems in the Old Sewage Treatment Plant likely were the consequence of plant waste discharges. A process waste outfall line was constructed in 1961 to convey plant wastes to the Rocky Branch Interceptor, the main line of the sewage collection system. Pretreatment of the process waste consisted only of pH neutralization and stabilization. However, other sewer lines had existed between the Arkansas Ordnance Plant and the Rocky Branch Interceptor, and it is possible that some plant wastes entered the sewer system through these lines not only before, but also after the construction of the process waste outfall. A manhole on one of these lines, manhole 71, was tested in 1979, when it showed 0.159 ppb dioxin, and again in 1981, when it showed 10.9 ppb dioxin.

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Prior to the arrangements for treating the plant waste, commercial fishermen and residents along Bayou Meto, a large watercourse south of the plant, frequently complained of odors in the bayou, odd odors and taste in fish, and also occasional fish kills. After the Old Sewage Treatment Plant began accepting the plant waste for treatment, the complaints continued, though they were reduced in number. As a result of the complaints, the Arkansas Pollution Control Commission conducted a special survey in the upper Bayou Meto basin in the first half of 1967. The study linked the problem with high five-day biochemical oxygen demand (BOD_5) loading and ineffective phenolics removal in the sewage treatment system.

The Arkansas Health Department quarantined Rocky Branch in the late 1970s from where it flows through the Vertac property to its confluence with Bayou Meto, and quarantined Bayou Meto from Jacksonville to where it flows into the Arkansas River. Commercial fisheries in the bayou have been banned by the Health Department since 1979 because of dioxin contamination.

The data collected by ADPC&E and EPA previous to the RI covered the period between June 1979 and May 1983 and gradually identified the magnitude of the potential offsite contamination problem. The following is an overview of the soil/sediment sampling prior to the RI.

The first samples were collected from June 1979 to August 1979 in the residential area south of the Vertac site. Among these samples 4.2 ppb dioxin was found in the rose garden at 2113 Braden Street, and 2.6 ppb was found on lot 21 on West Lane. All other samples contained less than 1 ppb dioxin.

In September 1979 the first samples were collected in Rocky Branch and Bayou Meto at some of the bridge crossings. Low concentrations of dioxin were found at most locations, except in Rocky Branch at the Highway 67/167 crossing, where 2.5 ppb was found, and Bayou Meto at the Highway 161 crossing, where 1.6 ppb was found. A few other locations were sampled in the residential area. At the Sewage Treatment Plant, one sample was taken from the north oxidation pond, where 8.37 ppb was found, and one from the south pond, where 7.75 ppb was found. The manhole at Braden and Alta Lanes was sampled and 0.159 ppb was found, and an unidentified location of the "Sewerline, Vertac to Jacksonville STP" had 1.13 ppb dioxin.

In May 1980, three soil samples were taken in DuPree Park. One at the "West Side Shoreline of Lake DuPree" contained 0.228 ppb dioxin.

In March and April 1981, samplings were repeated at some of the previously sampled points at bridge crossings of Rocky Branch and Bayou Meto, and some new points were added at these locations. All these samples contained less than 1 ppb. The sampling was also extended to the east and west legs of Rocky Branch in the residential area immediately south of Vertac. In the west leg, 0.27 ppb was found. In the east leg, 0.535 ppb was found. In a drainage ditch adjacent to the Vertac plant site at Marshall Road, 0.610 ppb was found. A composite sample collected from the sewage treatment plant north and south oxidation ponds contained 3.4 ppb dioxin. The manhole at Braden and Alta Lanes was resampled and 10.9 ppb dioxin was found. Several surface locations in the residential area were also sampled. None of the samples contained measureable concentrations of dioxin. The locations included are in the rose garden at 2113 Braden Lane, which had contained 2.6 ppb dioxin in 1979.

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In December 1981, some locations of Bayou Meto were resampled. Less than 1 ppb dioxin was found at all points.

In November 1982, another sampling was performed in the residential area. No measurable dioxin concentrations were found.

In May 1983, EPA performed additional sampling of the residential area. The samples were not analyzed for dioxin, however. Priority pollutants analyzed for were 2,4-D, 2,4,5-T, 2,4,5-TP, total chlorinated phenols, and total chlorinated benzenes. All but one location tested below the quantification limit. A composite sample from three locations in the front yard of 625 Carpenter Lane contained 2 ppb 2,4-D, and 1 ppb 2,4,5-T.

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Results of the samplings by EPA and ADPC&E through 1982 were compiled in the 1983 ADPC&E report, "Summary of Technical Data, Jacksonville, Arkansas." The data from all EPA and ADPC&E samplings are included in Table 5-1 of the present report.

The only study in the investigation area not performed by EPA or ADPC&E was performed by Environmental and Toxicological Consultants, Inc. (ETC), on commission from Vertac.

The ETC study was limited to three areas off the plant site: Rocky Branch, Bayou Meto, and Lake DuPree, a lake in a recreation area south of the site. The consideration of Rocky Branch and Bayou Meto was based on previous data gathered by EPA or ADPC&E, and concluded that dioxin in the watercourses was decreasing. New data were generated for Lake DuPree. The ETC report indicated that Lake DuPree sediments contained up to 192 ppt dioxin (see Appendix 7).

Most of the data from samplings prior to the RI are limited in terms of quality due to inadequate quality control in the field and in the laboratories and lack of accurate records concerning sampling methods and sampling locations. Due to these limitations, it is virtually impossible to compare sampling results or assess historical trends.

3. INVESTIGATION AREA DESCRIPTION

Information presented in this section was obtained from various reports published by the United States Geological Survey (USGS), the Arkansas Geological Commission, and research papers, supplemented by field observations by the RI team.

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3.1 GEOGRAPHY

The investigation area occupies approximately 36 square miles in and to the west, south, and east of the City of Jacksonville, Arkansas, 12 miles northeast of Little Rock. The investigation area lies along the Fall Line, a northeast-southwest-trending boundary of major physiographic and geologic provinces (see Figure 3-1). Southwest of the Fall Line in the Jacksonville area are unconsolidated Quaternary deposits of the Mississippi Embayment. North of the Fall Line are consolidated Paleozoic deposits of the Arkansas Valley Province.

The surface gradient in the area is generally to the south-southeast. There are two major drainageways in the area, Rocky Branch and Bayou Meto (see Map 1-2). Minor drainageways are intermittent streams that flow into Rocky Branch and Bayou Meto in the spring or during periods of heavy rainfall.

Rocky Branch originates near the northern boundary of Jacksonville and flows generally south, traversing the Vertac plant property along the west side. About 2 miles south of the Vertac plant it empties into Bayou Meto. Comparison of aerial photos from 1949, 1970, and 1984, as well as observations during the visual stream survey indicate the likelihood of Rocky Branch channel changes in the area between S. Redmond Road and Highway 67/167.

Being a young stream, Rocky Branch is characterized by low sinuosity, low levels of suspended sediments, and a high bed-load potential. Sediment load of Rocky Branch is derived from erosion of upgradient and surrounding terrain. Average sediment depth is about 10 inches. Channel deposits are predominantly silt and clay. Generally, both banks are steep, but there are occasional small point bars at meanders. Lag gravels are found on point bars and along the upper reaches of the stream. As the stream approaches Bayou Meto, the channel becomes wider and deeper and the sediments become finer.

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Bayou Meto begins in the Atoka Formation approximately one mile northwest of Jacksonville. At the Fall Line, Bayou Meto changes course from south to east, and due to bedrock changes, becomes broad and and sinuous. Also, the gradient decreases, resulting in sluggish water flow. Abandoned and partly filled channels with interconnecting oxbow lakes, ponds, and minor tributaries are common.

Sediments in Bayou Meto are generally fine grained sand, silts, and clays. Due to the sluggish water flow, gravel deposits are rare. Organics from vegetation decay also make up a large portion of the sediment. About 130 miles southeast of Jacksonville, Bayou Meto empties into the Arkansas River.

Bayou Meto and Rocky Branch flood frequently, depositing sediments in an extensive irregular floodplain along their banks. A floodplain delineation study was performed as part of this RI. The methodology and results are given in Section 4.1. The floodplain is bisected by U.S. Highway 67/167, state Highway 161, and the Missouri-Pacific railroad line, all of which are raised on earthen artificial embankments.

Several water impoundments exist in the investigation area (see Map 1-2). The largest of these are: Lake DuPree, a few hundred feet southeast of U.S. Highway 67/167, in the southern part of DuPree Park; a north unnamed impoundment, directly west of Lake DuPree, about 100 feet northwest of Highway 67/167; a middle unnamed impoundment, southwest of the north unnamed impoundment, about 100 feet northeast of Bayou Meto; a south unnamed impoundment, about 100 feet southwest of Bayou Meto and northwest of Highway 67/167. Lake DuPree and the south unnamed impoundment appear to have originated as borrow pits for the construction of Highway 67/167. The other two impoundments seem to be natural ponds.

Intermittent drainageways sometimes flow into these impoundments, and during high water periods, rivulets allow water from the impoundments to run off into Bayou Meto. Most of the time the impoundments lack outlets, however. The primary water source for the impoundments

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appears to be groundwater and rainwater runoff from surrounding areas. Sedimentation is also primarily from this source.

The climate of central Arkansas is relatively mild year-round, though extremes occur. Winter temperatures average 42°F, but can drop to 10°F. Summers are hot and humid. The average temperature is 82°F, though summer temperatures often exceed 100°F.

Precipitation is well distributed throughout the year, though spring is the wettest season. August and October are the driest months. September is not a dry month, however, and high intensity rainfall is not uncommon. Thunderstorms are very common, particularly in the summer and fall. An average of 56 days a year have thunderstorms, often accompanied by strong winds and hail.

Evaporation is an important element in the area meteorological system. During the summer, as much as 1/3 inch of water per day evaporates. Abundant sunshine and high temperatures can result in drought and a significant loss of soil moisture. Severe droughts occur once every 10 to 15 years.

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3.2 GEOLOGY

The investigation area lies along the Fall Line, a boundary of major physiographic provinces in Arkansas. Northeast of the Fall Line, the Arkansas Valley Province generally consists of consolidated Paleozoic Era materials with recent alluvium in stream valleys. Southeast of the Fall Line are unconsolidated Quaternary sediments of the Mississippi Embayment.

Table 3-1 presents a generalized geologic section of the investigation area. Map 3-1 illustrates the general geology of the area. The central area of the City of Jacksonville lies on Wilcox Formation. Wilcox is made up of weathered brown shale, gray micaceous shale, gray and gray-green siltstones and clay, and thick sand beds. The general strike of Wilcox deposits is northeast-southwest, with a southeasterly dip at a rate of 20 to 50 feet per mile. Some of the thick sand beds make excellent aquifers.

Underlying the Wilcox and on the outskirts of the city is the Midway Formation. Most of the Vertac plant lies on Midway deposits. Midway is found throughout the Mississippi Embayment subsurface and outcrops along the Fall Line. In the Jacksonville area it lies unconformably on Paleozoic bedrock. In the study area, the Midway Group is undifferentiated, but in other locations it has been divided into two members. An upper member is blue-gray to dark gray, fissile, flakey shale, containing sideritic, concretionary layers. The lower member consists of soft gray, calcareous, fossiliferous shale with basal lenses of white limestone. Structurally, the strike of the Midway is northeast-southwest, with horizontal beds along the Fall Line. Under the embayment, beds dip slightly southeast. In the investigation area, the Midway Formation is not known to provide water for wells. The basal limestone and sandstone lenses furnish water to domestic wells southwest of Little Rock, however.

Outside Jacksonville to the south and east, and underlying approximately three-fourths of the study area are Quaternary alluvial and

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terrace deposits of the Mississippi Embayment. These are Pleistocene Age deposits that are lithologically similar, overlain by fine sand, silt, and clay of recent age. The terrace deposits are on one or more terrace levels. Figure 3-2 illustrates a cross section of Quaternary alluvium taken from drill logs east of Jacksonville along Old Military Road. Quaternary recent alluvium has been divided into two units on the basis of where the units are found:

- Deposits of local streams or of overbank flows of major streams (in some areas these include deposits in abandoned meanders of major streams);

- Deposits in major stream channels or in mappable meanders of major streams (in some areas these include alluvial deposits in natural levees).

These deposits can be further broken down into two distinct lithologic units:

- Surface or upper alluvium is predominantly clay or silt with basal sand and gravel;

- A lower alluvial unit consists of a coarse basal sand and gravel grading upwards to a fine sand, silt and clay.

The northwest part of the area of investigation is Atoka Formation. The Atoka Formation is the most commonly found surface formation in the Arkansas Valley and is thought to underlie most Mississippi Embayment sediments. A small portion of the Vertac plant lies on Atoka Formation. It outcrops along the Fall Line escarpment, or is often covered with a thin veneer of Quaternary recent deposits and soil. South of the Fall Line the Atoka dips steeply to the southeast. North of the Fall Line the formation is very thick, perhaps 7,000 to 9,000 feet, and thins rapidly to the east. Atoka Formation consists of gray to black, splintery, finely to coarsely textured micaceous shale containing lenses of white, tan, or gray siltstone and fine to medium grained shaley sandstone. The Lower Atoka member found in the study area may also be characterized by dark colored chert and an interval of medium to dark gray flakey shale.

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Water is found in fractures in the rock, which become fewer and less open with depth. For this reason, water wells in the Atoka are shallow and rarely greater than 50 to 60 feet deep.

Isolated subsurface remnants of undifferentiated Cretaceous deposits are found near the Fall Line, though they do not outcrop in the investigation area. Hydrologically they are unimportant. Water found in them is often salty.

The above data were obtained from a literature search on the investigation area, and in particular the following sources: Boswell et al. 1968; Cushing et al. 1964; Dole 1916; Hosman et al. 1968; Plebuch 1960; and USGS 1967.

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3.3 SOILS

Soil associations are made up of one or more major soil units and some minor soils. Soil associations in the investigation area (see Map 3-2) can be grouped according to landscape types. There are three landscape types in the area. Each landscape type features distinctive patterns of soil units, relief, and drainage, and contains one or more soil associations. Some soils units are found in more than one association.

The first landscape type consists of upland sediments deposited in old coastal embayments, and local sediments washed from these and nearby uplands. This landscape type is made up of the Amy Association and Amy-Rexor Association in the investigation area. Amy Association soils are poorly drained level deep loams on broad upland flats. The surface layer is generally brown silt loam, and the subsurface layer gray, mottled silt loam. The subsoils are gray, mottled silt loam, and silty clay loam. Underlying material is light-gray, mottled silty clay loam. Fifty-eight percent of the association consists of Amy soils. The rest are Leadvale, Smithdale, and Tiak soils, and urban lands.

The Amy-Rexor association consists of poorly to well-drained, level to gently undulating, deep, loamy soils on floodplains and local drainageways. The association is made up of 55% poorly drained Amy soils, 40% well-drained Rexor soils, and 5% Leadvale and Guthrie soils.

The Amy soils in this association are as described for the Amy Association. Rexor soils have a surface layer of dark grayish-brown and dark yellowish-brown silt loam. The subsurface is brown silt loam. Subsoil is a dark brown mottled silt loam underlain by mottled silt loam. Rexor soils make up the well-drained portion of the association.

The second landscape type found in the investigation area consists of the sediments deposited between natural levees and in back swamps by

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large rivers, chiefly the Arkansas River. This landscape type is made up of Rilla-Keo and Perry-Norwood Associations in the investigation area. The Rilla-Keo Association is made up of 34% Rilla soils, 29% Keo soils, and 37% minor soils. Moreland silty clay is the most common minor soil in the association. All of the soils in the association are well-drained level to gently sloping deep loamy soils on bottom lands.

The Perry-Norwood Association consists of poorly to well-drained level deep clayey and loamy soils on bottom lands. It is made up of 45% Perry soils; 31% Norwood; and 24% Moreland, Keo, Bruno, and Umbraqualfs soils, clayey urban land, and water. As in the Rilla-Keo Association, Moreland is the most common minor soil in this association.

The third landscape type is made up of weathered material from predominantly level-bedded acid sandstone and shale, and valley fill washed from local highlands. This landscape type consists of the Linker-Mountainburg Association in the investigation area. The Linker-Mountainburg association consists of well-drained, gently sloping to steep, moderately deep to shallow, loamy to stony soils on hills, mountains, and ridges. The surface layer is dark yellowish-brown gravelly fine sandy loam and/or stony fine sandy loam. The subsoil consists of brown fine sandy loam, yellowish-red clay loam, and mottled clay loam. Sandstone bedrock underlies the subsoil.

Local Soils

The soil associations can be further divided by soil units. The soil units in the investigation area are shown on Maps 3-3 through 3-6, and Table 3-2. The soil units in the investigation area are:

- Amy Silt Loam (An). This soil type is found on moderately high ground and is therefore better suited for cultivation. Its wetness is a severe limitation.
- Amy Silt Loam, Frequently Flooded (As). This is the predominant soil in the immediate vicinity of the Vertac plant. It is formed from loamy alluvial sediments in the floodplains of local drainageways. Because of frequent

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flooding, this soil is not suited for cultivation or construction.

- Amy-Urban Land Complex (Au). This is a mixture of natural Amy soils and modified Amy soils for urban development. As with the other Amy soils, limitations are severe for most urban uses.

- Leadvale Silt Loam, 1 to 3% Slopes (LeB). This soil is formed from loamy sediments washed from the Ouachita Mountains. It can be found in valleys, on top of low mountains, and in the coastal plain. The erosion potential is moderate and is suitable for cultivation and urban development.

- Leadvale Silt Loam, 3 to 8% Slopes (LeC). This soil is much like the Leadvale silt loam, 1 to 3% slopes (LeB). Erosion potential is high because runoff tends to be moderate to rapid.

- Leadvale-Urban Land Complex, 1 to 3% Slopes (LdB). This is a complex of Leadvale soils and Leadvale soils modified by urban development. Vegetation is needed to keep this soil from eroding. The subsoil has a hardpan layer that restricts root movement and water movement. This unit is characterized by a perched seasonal water table and slow permeability.

- Linker Gravelly Fine Sandy Loam, 3 to 8% Slopes (LkC). This is a shallow residual soil from weathered igneous rocks. It is found chiefly on mountains and on benches. Erosion potential is severe. Runoff rates are moderate.

- Linker-Urban Land Complex, 3 to 8% Slopes (LnC). This soil consists of Linker soils and Linker soils modified by urban development. As with other Linker soils, depth to bedrock is 20 to 40 inches, runoff rate is moderate, and erosion potential is severe if vegetation is lacking.

- Moreland Silty Clay (Mc). This soil is formed from slack water bay sediments. It is found on level flood plains along the Arkansas River. It has a very high clay content, and thus very low permeability, slow runoff, and severe wetness during wet seasons.

- Rexor Silt Loam, Frequently Flooded (Re). This soil is much like the Amy series, except that it is well-drained. It is found on floodplains of local drainageways. Flooding is common, and so the soil is not suited for cultivation.

- Smithdale Fine Sandy Loam, 3 to 8% Slopes (StC). This soil is formed from loamy coastal sediments and is found on coastal plain uplands. Erosion potential is severe

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and the runoff rate is moderate. This soil can be used for cultivation or pasture only if conservation practices are followed.

The above data were obtained from various Soil Conservation Service publications, in particular, Soil Survey of Pulaski County 1975.

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3.4 GROUNDWATER

Groundwater exists in the interstices of porous or fractured geological formations. It flows in response to gravitational forces, usually at a very slow rate. Formations which are capable of yielding usable quantities of groundwater to a well or spring are called aquifers.

In the investigation area, all rock formations are capable of containing groundwater. In the relatively impermeable Atoka Formation rocks northwest of the Fall Line, most of the groundwater movement is through bedding planes and fractures. The unconsolidated rocks southeast of the Fall Line are more permeable, and so have greater quantities and higher rates of groundwater flow. In the area of investigation only the Wilcox and Quaternary formations can be considered aquifers.

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Wilcox Aquifers

The Wilcox Formation provides two distinct aquifers. The Lower Wilcox aquifer is the most important. This aquifer can yield 500 gpm to 2,000 gpm in some places. It is utilized as a water source east of Jacksonville, but not in Jacksonville or the investigation area.

The other Wilcox aquifer is referred to as the Minor Wilcox aquifer. In the heart of Jacksonville, where the Wilcox outcrops at the surface, there are three known water wells that utilize this aquifer. They are wells number 17, 19, and 20 on Table 3-3 and Map 3-7 (developed for the Water Use special investigation). At this location the Wilcox can be considered a shallow aquifer. Throughout the rest of the area, however, where it underlies Quaternary alluvial and terrace deposits, it is considered a deep aquifer. Wilcox aquifers in the investigation area consist of thin sand beds interbedded with clay. The yield and chemical quality of water from Wilcox aquifers differs widely due to the discontinuous nature of the sand matrix.

Quaternary Aquifers

Quaternary aquifers are also found in alluvial and terrace deposits in the area of investigation. These are shallow aquifers and recharge is primarily by infiltration from precipitation. Substantial seasonal water level variations occur because the majority of wells in these aquifers are used for irrigation. During the summer growing season, water levels can drop 10 to 15 feet because of over-pumping. These aquifers are part of the Mississippi River Valley alluvial aquifer which extends 380 miles from north to south and covers most of the west side of the Mississippi Embayment.

Quaternary alluvial aquifers are the principal groundwater source for the Jacksonville area. A majority of private wells depend on these aquifers. Formerly, the Jacksonville municipal water source was from Quaternary alluvial aquifers. Currently, Jacksonville gets its water from sources outside the investigation area. Present data (see Table 3-3) indicate that even though pumpage from area wells has increased, no significant decline of the water levels has occurred. Map 3-8 shows the approximate boundaries of local groundwater aquifers and the locations of wells utilizing these aquifers.

There are three categories of Quaternary alluvial aquifers in the investigation area: surface and lower alluvial aquifers, based on surface and lower lithologic units, and an alluvial aquifer in stream valleys overlying Atoka deposits. Except for low pumpage domestic wells, the surface aquifer is rarely used due to its low yield of less than 50 gpm. The lower alluvial aquifer constitutes the most important aquifer in the area, with yields similar to Wilcox, ranging from 500 gpm to 2,000 gpm. The alluvial aquifer in stream valleys overlying Atoka deposits exists in the northwest part of the area of investigation, but is not known to be used as a water source.

Major Quaternary water-bearing zones are generally confined, being overlain by sediments with lower permeability. Aquifer characteristics depend on the size and sorting of the host lithologic unit.

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Because these vary considerably from place to place, a quantitative statement on hydraulic characteristics cannot be made.

Groundwater table elevations in both shallow and deep aquifers fluctuate with season and usage. Potentiometric surface indicates the altitude to which water would rise in tightly cased wells at any given point. Map 3-9 shows the potentiometric surface contours of the Quaternary alluvial aquifer. Static water level elevations on the map are taken from Table 3-3, developed for the Water Use special investigation. The fluctuation of water levels indicates that the readings were taken at different times of the year. Potentiometric surface contours indicate general regional flow pattern. Groundwater movement in the aquifer is perpendicular to the contours. Except in local areas heavily affected by pumping, the gradient in the investigation area is basically south-southeast.

Quaternary alluvial water in the investigation area is typically of the calcium bicarbonate type. The calcium content ranges from 4 to 85 ppm; magnesium 1 to 21 ppm; sodium 3.4 to 20 ppm; and bicarbonate 15 to 282 ppm. Analysis of water from wells indicates that the water north of Bayou Meto is less hard and contains less calcium and dissolved solids than typical alluvial aquifer water. Most alluvial aquifers throughout the area have a high iron content, ranging from 0.12 to 6.8 ppm.

Other units in the area are the Atoka and Midway formations, and undifferentiated Cretaceous deposits. These do not yield sufficient water for domestic use, however.

The above data and the hydrogeological interpretations were developed from the special investigation groundwater study completed for this RI (see Section 4.5), as well as data from the USGS and the Arkansas Geologic and Conservation Commission, in particular: Counts 1957; Cushing _et al_. 1964, 1970; Dole 1916.

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3.5 LAND USE/POPULATION

Land use in the investigation area is a mixture of residential and agricultural with extensive undeveloped and uninhabited woodlands in the area near the confluence of Rocky Branch and Bayou Meto (see Map 1-2). The portion just south of the Vertac plant site, between Marshall Road and the Missouri-Pacific railroad tracks, south to W. Main Street, is residential, a combination of single-family homes and apartments. The section immediately west of the railroad tracks and north of W. Main Street is undeveloped. The area between W. Main Street and S. Redmond Road is commercial and light industrial. Just south of S. Redmond Road is undeveloped, uninhabited land that includes the Jacksonville Sewage Treatment Plant, DuPree Park, and Lake DuPree. The rest of of investigation area is either farmland, mainly irrigated rice fields in the area south of Jacksonville and Bayou Meto, woodlands, or residential. There is substantial suburban residential development on the strip of higher ground along Highway 161 and in the area north of Bayou Meto.

The investigation area is partly within and partly adjacent to the City of Jacksonville. Jacksonville has a total population of 27,589 people, according to the 1980 census. There are 7,378 families and 8,787 households. The population growth of Jacksonville has been as follows: 1950 - 2,474; 1960 - 14,488; 1965 - 18,078; 1970 - 19,832; and 1980 - 26,788. The population in the area of investigation outside Jacksonville is estimated to be about 3,300.

The above information was drawn from various publications on the Jacksonville area from state and local agencies and the Jacksonville Chamber of Commerce.

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3.6 SEWAGE SYSTEM

Jacksonville has a combined sanitary and storm sewer. The first sewage treatment plant was constructed about 1941. It consisted of two Dorr type clarifiers to remove settleable solids, two trickling filters, and two secondary clarifiers. This plant, known as the Old Sewage Treatment Plant, is shown on Map 3-10. No records exist regarding cleaning practices or the removal and disposal of sludges. The treatment plant effluent may have been conveyed by a ditch to Rocky Branch.

In 1961, the plant was improved by rehabilitation of the pumping station and clarifiers, and addition of a sludge digester, sludge drying beds, gas heating equipment, and 44 acres of oxidation ponds. At present, there is no solids removal beyond the sedimentation taking place in the aeration and oxidation ponds. Sludges are not removed from either the aeration or oxidation ponds.

At that time the utility agreed to accept and treat wastes from the pesticide plant on the Vertac site. A process waste outfall line was constructed to convey wastes from the plant to the Rocky Branch Interceptor. The only treatment of the waste that entered through the outfall line was pH neutralization and stabilization. It was not anticipated that the pesticide plant waste would also be high in organic load. The treatment plant was designed to be able to treat 3,560 pounds per day of 5-day Biochemical Oxygen Demand (BOD_5). A 1967 survey indicated the total BOD_5 in the treatment plant influent was 7,650 pounds per day. In spite of this overload, the average BOD_5 in the effluent from the stabilization ponds was only 55 mg/l, including the BOD of the algae. During the winter, however, when algae is reduced, the removal of BOD and phenols was poor.

To solve the problem, a 3-acre aerated lagoon prior to the oxidation ponds was built in May 1969. This complex, known as the New Sewage Treatment Plant, is shown on Map 3-11. All treatment units upgradient of the aeration lagoon were then abandoned. At present, the primary

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clarifiers are full of water. The east trickling filter is partially filled with rocks; the west filter is filled with rocks; the secondary clarifiers are empty, except for some sediment in the bottom; the sludge digester is full; and the sludge beds are used for vegetable/flower gardens. It is estimated that the volume of sediments in the Old Sewage Treatment plant components is about 500 cu yds.

Many of the sewer lines were constructed in 1941, at the same time as the Old Sewage Treatment Plant and the Arkansas Ordnance Plant were constructed (see Map 3-12). Some of these lines received sewage from the ordnance plant and likely received wastes from the pesticide plants prior to the 1961 agreement by the utility to accept and treat pesticide plant wastes conveyed through the process waste outfall line. Moreover, it is possible that some of these lines have continued to receive untreated pesticide plant wastes after 1961.

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The original lines remain in service today, except for approximately 4,600 feet of the Old Rocky Branch Interceptor, the main north- south line. This segment was replaced in 1979 by the new Rocky Branch Interceptor because of infiltration problems. The new line is located parallel to, immediately east of the old line. The replaced segment of old line was disconnected at each end but remains in place and contains water and sediment. It is not known whether the old and new lines are isolated. It is possible that at some points they are interconnected. The old and new lines are shown by the double line on Map 3-12. A small segment of sewer line between manholes 76 and 77 was rerouted in 1949.

New residential lines have been added over the years. The sewage flows from the lateral and interceptor lines to an underground pump at the treatment plant pump house. From there it is conveyed to the aeration basin, and then to the oxidation ponds. After treatment, the effluent is conveyed via an outfall ditch to Bayou Meto.

The engineering work on the Future Sewage Treatment Plant started in 1975, and the plans and specifications were completed in 1983 (see Map 3-13). The future plant, to be located southeast of the city, will be an extended aeration activated sludge process plant with an oxidation ditch type configuration. Advance treatment includes gravity filtration. Plant design capacity is 6 MGD. Sludge treatment is accomplished through thickening by diked containment.

General problems that have been noted over the years with regard to the sewage system include overflows in the area near the Vertac plant, often lasting a week or more, during heavy rainfall periods; infiltration of stormwater runoff and possibly of groundwater; and possible exfiltration during periods of low groundwater. The sewage collection system lamping performed in conjunction with the RI revealed evidence of infiltration, and defects in lines and manholes that would allow infiltration and exfiltration.

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3.7 POTENTIAL PATHWAYS AND IMPACTS OF CONTAMINATION

Possible contamination on the Vertac Plant site could reach offsite areas through a variety of media and physical features.

The majority of plant site surface runoff drains into the west leg of Rocky Branch, and other surface runoff drains into the east leg, which joins the west leg just north of W. Main Street. Surface runoff may also drain into the combined storm and sanitary sewer system which serves the plant site and areas south of the site. Other runoff drains into the residential area south of the site and into the sewer system in that area. In the recent past, state and federal permits have regulated storm runoff discharge from the plant site into the sewage collection system. Compliance with these regulations and onsite remedial work should minimize further contamination of surface water by plant runoff.

007102

Downstream of West Main Street, Rocky Branch traverses a light industrial and commercial area extending to S. Redmond Road. Further downstream, between S. Redmond Road and Highway 67/167, there are indications the stream channel may have been altered either naturally or artificially. Thus, Rocky Branch in-stream sediments may exist in areas other than the present stream channel.

Rocky Branch flows into Bayou Meto, the major watercourse of the area. Thus, contamination from Rocky Branch could reach Bayou Meto, which flows into the Arkansas River several miles downstream from the investigation area. Contamination could also reach Bayou Meto, from the Sewage Treatment Plant outfall about three-quarters of a mile upstream of the mouth of Rocky Branch.

Wastes from the pesticide plant may have been conveyed to the sewer system as far back as the late 1940s. Since 1961, pesticide plant wastes were conveyed to the Rocky Branch Interceptor via the process waste outfall line. It is also possible that both before and after

1961 some pesticide waste was conveyed to the sewer system through sewer laterals located on the Vertac site.

- Thus, the sewage collection system may have become contaminated including both the abandoned and new Rocky Branch Interceptors. The collection system is aged and defects in the line could have allowed exfiltration during low groundwater periods, resulting in contamination of groundwater. Overflows of the collection system which have occurred over the years, especially near the plant, could also have conveyed contaminants to flooded and sewer overflow areas, including the residential area south of the plant site and adjacent undeveloped areas.

From the sewage collection system, contamination would have been conveyed to the Old and New Sewage Treatment Plants and would have contaminated plant facilities. The aeration basin and oxidation ponds of the New Sewage Treatment Plant are open lagoons. Discharge from the oxidation ponds is via overflow weirs. High winds could remobilize sediments in the ponds, resulting in sediment discharge through the weirs. The lagoons could also overflow, conveying contaminants to surrounding surface areas.

From the Old Sewage Treatment Plant, contaminated effluent may have been conveyed to Rocky Branch via a conduit that may have existed south of S. Redmond Road. This conduit appears to have been the discharge line from the old sewage treatment plant, prior to the construction of the oxidation ponds and outfall ditch. Some contamination may also have been conveyed, through a drainage course under Highway 67/167 approximately 1,000 feet north of the present 67/167 bridge over Rocky Branch, to the area presently occupied by Lake DuPree. From the New Sewage Treatment Plant, effluent flows via the outfall ditch to Bayou Meto.

Rocky Branch and Bayou Meto flood frequently. During floods, any contaminants in the watercourses could be carried into and deposited on the floodplain. The floodplain also includes several water impoundments which could receive contaminants from the floodwaters.

007103

The oxidation ponds of the sewage treatment plant would be inundated by 5-year frequency floods. This would result in mixing floodwaters and oxidation pond waters, and contaminants in the oxidation pond waters could be carried off in the floodwaters.

The complex, variable topography, vegetative cover, and geographic features, such as river bends, dikes and levees, and railroad and highway crossings, of the floodplain create complex flow patterns and sediment scour and deposit activity. The flow patterns and scour and deposit activity can change over time depending on man-made or natural changes of physiography, or on the depth, velocity, and magnitude of the floodwaters. The process could result in dioxin-contaminated sediments being deposited in layers at various depths or in deposits being remobilized and redeposited in new areas.

Heavy rainfall is another important transport mechanism in that it causes erosion and could also induce a downward movement of fine soil particles to which dioxin may be attached.

Irrigation with Bayou Meto waters could result in contaminants in the water or in sediments extracted with the water being deposited on farmlands or in irrigation ditches. Cultivation breaks up the soil and could transfer contaminants in the soil either deeper into the ground or laterally. Soil removal for land development would also relocate contaminants in the soil.

In spite of the low water-solubility of dioxin and its tendency to bind to soil, groundwater cannot be ruled out as a possible pathway of dioxin migration. Groundwater contamination could occur through percolation of waters from the surface or through exfiltration from the sewage collection system.

Wind-borne contaminated particles could also constitute an air pathway of dioxin migration.

007104

Routes of Exposure

Exposure to the resident population in the investigation area could occur through ingestion of contaminated water or food or by dermal or respiratory contact with contaminated soil or other particulate matter. Accurate estimation of the risk associated with dermal contact with contaminated soil particles is difficult.

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In assessing exposure concentrations of contaminants, duration of exposure, type of activities in contaminated areas, specific exposure mechanisms, and access to contaminated areas should be considered. Three exposure routes applicable to contamination of residential areas are: dermal absorption through direct soil contact; ingestion of soil; and inhalation of particles to which dioxin is adsorbed. Vapor exposure is another possible minor route of exposure. If dioxin enters the food chain, especially through bioaccumulation or biomagnification in fish, an additional risk may be present.

Acute and Chronic Toxicity in Animals

Dioxin is known to be one of the most toxic substances to mammalian species. Depending on the species, the acute and chronic toxic doses generally show a wide variation in the submicrogram to milligram range. For example, the reported oral LD_{50} values for dioxin range from 0.6 ug/kg for guinea pigs to 5,051 ug/kg for hamsters.

An interesting feature of short-term toxicity tests with dioxin is that they have revealed an unusual temporal dependence. That is, acute toxicity tests are often run for time intervals of a few days to 2 weeks. Tests with dioxin reveal mortality in a time range of 5 days to 6 weeks. This prolonged interval and the variety of dioxin-induced tissue anomalies across the species investigated have thus far confounded attempts to determine the exact cause of death.

Carcinogenicity

There have been at least six reported chronic animal studies investigating the carcinogenicity of dioxin. One study often used for dioxin risk assessment was that of Kociba (1977). In that study, ingestion of 0.1 μg/kg/day caused an increased incidence in carcinomas of liver, lungs, and mouth, while decreasing the incidence of tumors of the uterus and pancreas, and pituitary, mammary, and adrenal glands. Tissue samples from animals at this dose level contained 24 ppb dioxin in the liver, and 8.1 ppb in fat. The increased incidence of tumors in the lungs and liver at the high dose of this study occurred only in female rats, while the oral-nasal tumors were significant in males. The authors also noted that at this dosage the animals manifested other signs of significant toxicity including increased mortality, decreased weight gain, depressed erythroid parameters, increased excretion of porphyrins and aminolevulinc acid, and evidence of liver damage determined by elevated serum activities of alkaline phosphatase, gamma-glutamyl transferase, and glutamicpyruvic transferase. At dosages 10 and 100 times lower than 0.1 ug/kg/day, the chronic toxicity of dioxin diminished to nothing and there were no significant increases in tumors when compared to the control animals. Thus, it was concluded that during this 2-year study in rats, no increase in tumors occurred at dosages of dioxin causing slight or no manifestations of toxicity.

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Teratogenicity, Fetotoxicity, Reproductive Effects

Dioxin is fetotoxic at maternally toxic doses in rats, mice, and monkeys (Smith 1976). In mice, doses of 1 ug/kg/day or greater consistently produce fetal defects such as cleft palate and kidney anomalies. At doses lower than 1 μg/kg/day, no teratogenic or fetotoxic effects occurred, indicating that there is a "no effect" exposure level. It has been established (Barsotti 1974; Courtney 1976) that chronic dosages of 1 μg/kg/day or higher affect the reproductive capacity of rats and monkeys. The increased abortion rates occur at dosages which again are maternally toxic. Barsotti, using rhesus monkeys, concluded that the debilitating toxicity seen at the dosage used (2 μg/kg) may have caused the reproductive dysfunctions. The authors also found that the surviving animals returned to a normal reproductive status once they were removed from exposure to dioxin. In another study (Murray 1979) which determined the effect of dioxin on three generations of reproduction in rats, it was concluded that 0.001 ug/kg/day had no effect, while 0.01 and 0.1 µg/kg/day clearly affected normal reproduction. In summary, it appears that dioxin is teratogenic and does affect reproduction in animals, but also that there is a "no effect" exposure level.

Other Effects

Dioxin exposure may have many adverse effects other than cancer, reproductive dysfunction, and mortality. Among these effects are skin lesions (chloracne), liver damage, and kidney damage. Intestinal absorption of nutrients is also altered after dioxin exposure; some nutrients are absorbed more readily and others less readily.

Experiments show that dioxin exposure may effect the hematopoetic system. In some species, the blood cell count is changed. The immune response system may also be altered. Exposure to dioxin beyond a "no effect" level decreases spleen and thymus weight. Cell-mediated immunity is hindered, especially T-lymphocyte function. Immunoglobulin production is also reduced. The exact mechanism of dioxin-related immunotoxicity is being investigated at this time.

Human Effects

The most recent data on human exposure to dioxin are the findings from the Seveso incident in Italy (Reggiani 1979). A study of human exposure from this incident divided persons into two zone groups, Zone A and Zone B. In Zone A the average contamination was 50 $\mu g/m^2$, and 447 inhabitants were studied. Zone B had 362 inhabitants and 3 $\mu g/m^2$ dioxin, plus 156 plant workers in the factory where the explosion occurred. Chloracne was the major and most consistent effect. The peripheral nervous system studies revealed subclinical changes in 10% of the people living in the area of highest contamination. There was no correlation between the neurological findings and chloracne. Transient signs of liver damage without functional disorder occurred in 10% of both groups. The immunologic responses of the two populations were not impaired. There was no increase in fetal deaths, birth

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defects, or growth retardation out of the 7,350 births occurring in the first two years after the incident. Chromosome examinations did not reveal any changes from the normal pattern. Thus, Reggiani concluded that "man has a higher degree of tolerance to TCDD than a direct extrapolation from animal data would suggest." The conclusion is supported by the data gathered on the one exposed person who died during this study. The body of a 55-year-old woman who died seven months after exposure from pancreatic carcinoma unrelated to the accident was analyzed for dioxin after autopsy. The woman had been exposed to dioxin from the explosion and had lived in a contaminated area (162 to 1847 $\mu g/m^2$) for 15 days. The total body burden of dioxin was calculated to be 40 μg at the time of death. Of course she would have eliminated some dioxin in the 7-month interval between exposure and death. Even though the amount eliminated cannot be calculated, the analysis indicates that the people included in this study accumulated large amounts of dioxin without exhibiting any serious adverse effects up to the time of the study. It should also be noted that the amount of dioxin absorbed was 1,000 to 3,000 times higher than the tolerable amounts calculated using rat or guinea pig acute toxicity data.

007108

4. SPECIAL INVESTIGATIONS

Seven special investigations were conducted as a part of the Remedial Investigation. These were: a floodplain delineation study; a Sonar survey of the impoundments in the study area; a water use inventory; a sewage collection system lamping; a groundwater study; an investigation of drums discovered during the RI; and an aquatic biota study.

Data on these special investigations, including their purposes, methods, and results are given below.

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4.1 FLOODPLAIN DELINEATION STUDY

A floodplain delineation study was performed to define the 2-, 5-, 10-, 25-, and 50-year flood areas along Rocky Branch and Bayou Meto. The objective was to determine the boundaries of areas where contaminants may have been carried and deposited by floods.

The study area included a segment of Bayou Meto from a point about 2 miles downstream from Arkansas Highway 161 to about 2 miles upstream of Highway 67/167; and a segment of Rocky Branch from its confluence with Bayou Meto to about 2 miles upstream.

Using historical floodwater surface elevation data, discharge data from three gaging stations in the area, and the report "Floods in Arkansas, Magnitude and Frequency Characteristics through 1968" (Patterson 1971), peak discharges were computed for the various flood events for selected cross sections along Rocky Branch and Bayou Meto (see Map 4-1 and Tables 4-1 and 4-2).

Patterson divides Arkansas into two regions, A and B. Region A features relatively flat terrain, and Region B features steep terrain and consequently higher velocity discharges. Parts of the investigation area are in Region A and parts in Region B. Most of Rocky Branch is in Region B, and so discharges along Rocky Branch were computed using Region B equations. Professional judgement and interpretations were used in assigning discharges along Bayou Meto to one category or the other. The J-635 step-backwater computer program was used.

Using the peak discharge information, together with data from the visual stream survey along the selected segments, and coefficients for channel roughness, water surface profiles at the cross sections were calculated for the various flood events. From these data, water surface profiles were developed for the selected stream segments (see Figures 4-1 and 4-2).

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The water surface profile data for the 2- and 5-year floods were then plotted onto a 1-foot contour topographic map (see Maps 4-1 to 4-6). The floodplain maps were used in the development of sampling plans.

Appendix 8 presents technical details on the floodplain delineation method.

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4.2 SONAR SURVEY

In conjunction with the August 1984 sampling, a sonar survey was performed to determine the bottom topographies of Lake DuPree, the north, middle, and south unnamed impoundments, and the Sewage Treatment Plant aeration basin and oxidation ponds.

A Lowrance Electronics, Inc., Model No. UX15A sonar unit was used. Traverse lines at regular intervals were marked off for each impoundment. A rope marked at 10-foot intervals for reference points was stretched across an impoundment along a traverse line and anchored on each shore. A boat was then pulled slowly along the rope and continuous readings were taken. The sonar recording unit, located in the center of the boat, produced a cross section along the traverse line. The transducer was mounted at the stern. If an irregularity occurred, the survey along that line was repeated. When the survey along a given traverse was completed, the rope was moved to the next traverse and the procedure repeated.

The survey results were used in the field for selecting sediment sampling locations in the impoundments. Sediment depths were estimated at each sampling location. Subsequently, bottom contours were developed from the sonar cross sections, and sediment and water volumes were calculated.

Sonar survey data on each impoundment are described below. In calculating sediment volumes the original design depths of 6 feet for the oxidation ponds, and 12 feet for the aeration basin were used. For the other impoundments, volumes were estimated based on the surveyed top of sediment configuration and field estimations of sediment depths. The estimated sediment depths ranged from a few inches to a couple of feet. Calculated water and sediment volumes are listed in Table 4-3.

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Lake DuPree

Six east-west traverses were run across Lake DuPree. The first traverse was 100 feet south of the northern bank, and the others spaced at 200 foot intervals (see Map 4-7). The lake is 4 to 5 feet deep for the most part. One small portion is 6 feet. The sonar cross sections are shown in Figures 4-3 and 4-4.

North Unnamed Impoundment

Four southwest-to-northeast traverses were run at 100-foot intervals across the north unnamed impoundment (see Map 4-8). A large part of the impoundment is between 4 and 6 feet deep. The shallowest part is in the southeast (see Figure 4-5 and 4-6).

Middle Unnamed Impoundment

The first traverse across the middle unnamed impoundment was run in an east-west direction, 75 feet from the northern bank, and then three others were run at 100-foot intervals (see Map 4-9). There is a 12-foot-deep section in the northeast corner of the impoundment (see Figure 4-7).

South Unnamed Impoundment

The first traverse across the south unnamed impoundment was run in an east-west direction 100 feet from the north bank, and four others were run at 200-foot intervals (see Map 4-10). The depth of the impoundment is generally 6 feet, with parts down to 8 feet (see Figures 4-8 and 4-9).

Aeration Basin

Nine southeast-to-northwest traverses were run across the Sewage Treatment Plant aeration basin (see Map 4-11). The distances between the traverses were irregular due to physical obstructions posed by aerators in the basin. Another traverse was run longitudinally down

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the center of the basin, perpendicular to the nine traverses (see Figures 4-10 and 4-11). The bottom topography of the basin is varied due to scour and sediment accumulation created by the aerators and the intake line. The figures also show surface clutter picked up by the sonar signal. The basin is 12 feet deep in one part.

Oxidation Ponds

Performing a sonar survey of the Sewage Treatment Plant oxidation ponds was impossible due to the many shallows in the ponds. When the ponds were sampled, however, water depths and sediment accumulations were observed at the sampling points. The bottom contours are estimated. The contours are shown on Map 4-12. The estimated maximum depth is 5 feet in each pond. It was not possible to refine the map to show the many shallow shoal areas.

007114

4.3 WATER USE INVENTORY

An inventory of surface water and groundwater use in the Jacksonville area was performed. Pulaski County and sections of Lonoke County were covered in a general inventory, and a more detailed inventory was made for the investigation area.

The purpose of the water use inventory was to determine the locations where surface water and groundwater are withdrawn and the uses of such water. Federal, state, and local government agencies which could have information on water use in the area were contacted. Groundwater information was obtained from the United States Geological Survey (USGS); Arkansas Committee on Water Well Use; Arkansas Department of Health; and Arkansas Geological Commission. Surface water information was obtained from the Arkansas Soil and Water Commission.

Groundwater records dating back to 1960 and surface water records back to 1964 were found. The records reflect only data received from the cooperating public, however. It is likely that water use was larger than was reported.

Surface Water

Surface water in Pulaski and Lonoke counties is used by waterfowl and for irrigation, recreation, public water supply, livestock watering, and fish farming. Table 4-4 contains a summary of surface water use between 1960 and 1980, as reported by the USGS.

Irrigation of rice fields is the predominant surface water use in the area. Irrigation is also used for soybeans, cotton, fruit trees, and miscellaneous crops. Peak withdrawal months are May, June, and July. Rice irrigation in Pulaski County increased from 0.14 MGD to 2.97 MGD from 1960 to 1980. Lonoke County shows a general increase from 0.57 MGD to 45.29 MGD, with the exception of a drop in 1970. Irrigation of row crops in Pulaski County follows an upward trend, while in Lonoke County it fluctuates, averaging 2.75 MGD.

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Surface water use increased between 1960 and 1980 for every use except fish and and minnow farming, for which the usage declined, and livestock, for which it remained constant. In Pulaski County, public water use increased nearly four-fold. Recreational uses were not documented by any contacted agency. However, agency sources generally believe that Bayou Meto and its tributaries and area impoundments were more used for recreation in the past than they are at present.

In the offsite investigation area, also, most surface water is used for irrigation. The main surface water withdrawals are from Bayou Meto and its tributaries, and the several impoundments.

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Map 4-13 shows the approximate locations of surface water withdrawals in the investigation area. The locations indicate irrigation areas. Table 4-5 lists surface water withdrawal points for all uses in the Jacksonville area. The information was obtained from the Arkansas Soil and Water Conservation Commission and is based on voluntary self-reporting.

Municipal water drawn from surface water is from outside this area.

Groundwater

Groundwater use in Pulaski and Lonoke counties and in the investigation area includes domestic and public water supplies, irrigation, livestock watering, and industrial use. Table 4-4 includes a summary of groundwater use from 1960 to 1980 for the two counties. (Table 3-3 is a listing of water wells and withdrawals in the investigation area.) According to these data, groundwater use increased since 1960. The table lists total water use in each category. Specific withdrawal locations were not recorded.

Rural domestic groundwater use in Pulaski county increased considerably between 1960 and 1980, from 0.14 MGD to 5.80 MGD. Use in Lonoke County also increased, but not as drastically, from 0.55 to 1.42 MGD. Groundwater use for livestock remained almost constant for both counties. Pulaski County averaged 0.19 MGD and Lonoke County 0.3 MGD.

Fish and minnow farming in Lonoke County used a considerable amount of groundwater from 1965 to 1975, ranging from 53.66 MGD to 95.15 MGD. These figures dropped to 0 in 1980. Pulaski County groundwater for fish and minnow farming averaged approximately 1.75 MGD over the period 1965 to 1980.

Industrial groundwater use from private wells varied widely between 1960 and 1980 in both counties, ranging from 6.73 MGD to 0. Most of the industrial use is outside the investigation area, however. Fuel/electric power use for Pulaski County declined from 1965 to 1975, but increased slightly in 1980.

Residential groundwater wells for the offsite investigation area are shown on Map 3-8. These data were derived from USGS, the Arkansas Department of Pollution Control and Ecology, and the Arkansas Geological Commission. It is likely that many more wells exist in the investigation area. The Arkansas Well Commission lists wells constructed in the investigation area. The staff of the AWC believes that the number of wells could be as much as three times higher.

Municipal Water

According to the Arkansas Department of Health, the City of Jacksonville water supply is from three sources. First, the city contracted with the City of North Little Rock for 3 MGD of water from the North Little Rock water treatment plant. This water is delivered via a 24-inch main on the western side of the Jacksonville distribution system. The second source is the Lonoke County well field. Water from this source amounts to 6 to 7 MGD and is treated at the Jacksonville East Water Treatment Plant. The third source, the McClain well field, has the potential to provide approximately 2.5 MGD, but is presently inactive. Water from this source is hard, with high iron and manganese contents. Water from the well field is treated at the Jacksonville West Treatment Plant.

Lonoke County groundwater use for public water supply gradually increased from 0.69 to 2.54 MGD between 1960 and 1980, while use in

Pulaski County remained constant, with only small fluctuations. The average use was 3.55 MGD from 1960 to 1980.

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4.4 SEWAGE COLLECTION SYSTEM LAMPING

Sewer lamping is a procedure in which a light is directed through the sewer line from one manhole to the next to allow visual inspection for sewer integrity, alignment, obstructions, infiltration, and sediment accumulation. Lamping of 24,042 linear feet of selected lines (see Map 4-14) between the Vertac plant site and the Sewage Treatment Plant was performed between December 27, 1984 and January 24, 1985. The lamping was performed on 109 manholes. Due to poor weather conditions, an electrically powered spotlight was used instead of sunlight. The spotlight was reflected by two mirrors.

Data from the lamping are shown on Map 4-14. The sewer pipes were constructed of three different materials: clay, concrete, and ductile iron. Lines under street and railroad crossings were ductile iron, since it was necessary to construct these lines via a boring instead of an open cut. Concrete pipe, was used for most of the laterals. Pipe sizes of the lamped sewer lines ranged from 6-inch to 24-inch in diameter. The clay pipe was 10-inch or larger in most cases. Most of the concrete pipe was 6-inch. Table 4-6 lists the sizes and materials of each line segment between manholes. Table 4-7 gives total lengths by size and materials of all pipes surveyed.

The Jacksonville Wastewater Utility assisted in the lamping, and was advised when irregularities were found. The detected irregularities resulted in an investigation by utility personnel. Findings of the utility's investigation are provided in Appendix 9.

<u>Structural Defects</u>

The most serious of the structural defects was in manholes on the Vertac plant site. Six of the 14 manholes onsite had defects, and one of them is deteriorating from being splashed with treating material from the plant. Manhole 126 on the Vertac plant site presents the most obvious infiltration problem. The manhole bricks are missing below the rim, and a portion of Rocky Branch that was recently

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diverted from the plant cooling pond flows directly into the manhole and on both sides of the manhole.

Very few other structural defects were found. These ranged from initial construction defects to loose or broken manhole covers. The walls of manhole 75 had mud and water seeping through them. The top of manhole 1155 is flush with a concrete paved ditch allowing the ditch discharge to enter the manhole. One line allowed infiltration at manhole 126 into the sewer, while two other lines were broken and off-line.

It appears that damages to manholes in the abandoned Rocky Branch Interceptor are mostly due to the construction of the new Rocky Branch Interceptor, but some of the damages may have occurred after construction was completed. Table 4-6 contains a complete list of structural damages and infiltration found during the lamping.

Obstructions

Primary obstructions found in the lines consisted of grease, roots, dirt, and gravel. Grease was the most common obstruction encountered and was found to be most pronounced between manholes 1206 and 1208, near an apartment complex. Vines and roots were found in the line between manholes 1153 and 1154, and an unknown blockage was found between manholes 18 and 1202. Throughout the lamped lines, bricks and concrete from manholes had fallen into the lines and obstructed flow. Specific locations of the obstructions are shown on Table 4-6 and Map 4-14.

The lamping in the subdivision area showed that lines are off- line and off-grade. It was determined that the lines were constructed with a spirit level.

Sediments

Sediments were found in three main components of the system: in the abandoned Rocky Branch Interceptor, in the lower elevations of the

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laterals, and in the manholes (see Table 4-6). The sediments in the abandoned interceptor are largely a result of its stagnant state and various degrees of infiltration due to its deteriorating condition. In the laterals, sedimentation primarily results from infiltration or blockage in the lines. Accumulation of sediments in the manholes occurs as a consequence of mode of construction, deteriorating condition, infiltration, and line blockage. Total sediment found in the manholes of the surveyed lines is 3.4 cu yd. This figure may be further broken down to 1.12 cu yd in the abandoned Rocky Branch Interceptor manholes and 2.28 cu yd in the active system manholes, including those of the current Rocky Branch Interceptor. Most of the sediment in the sewer lines was in the abandoned Rocky Branch Interceptor, which had 35.55 cu yd. The active system contained 7.56 cu yd, resulting in a total of 43.11 cu yd in the sewer lines. Thus, the total sediment in the sewage collection system is estimated at 46.51 cu yd.

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4.5 GROUNDWATER STUDY

A groundwater investigation was conducted to identify aquifers, groundwater movement, and groundwater quality. The area of investigation covered approximately 36 square miles around the City of Jacksonville, concentrating on groundwater southeast (downgradient) of Vertac.

The groundwater investigation involved compiling data from several sources including: USGS publications on regional groundwater hydrology and water resources for eastern Arkansas; and Arkansas Geological Commission water resources publications on groundwater resources by county and community.

Findings of the groundwater investigation are given in Section 3.4, Investigation Area Description - Groundwater.

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4.6 DRUM INVESTIGATION

An investigation of 33 drums of unknown origin and content at the Jacksonville Sewage Treatment Plant was performed in November 1984. The 33 drums were discovered during the August 1984 sampling. The drums were found among shrubs and appeared to have been there for a long time. They did not show any distinguishing characteristics or markings. Initially it was suspected they might contain pesticide waste from Vertac.

An investigation was undertaken to learn the exact number of drums, the owner, contents, and origin. Preparation for drum opening was made and laboratory analysis of content samples was to be made.

After contacting several local agencies, however, it was determined that the barrels belonged to the Jacksonville Fire Department and contained a resin that when burned produced a large black cloud with an obnoxious odor. The department had obtained the drums by donation from U.S. Chemical Company. The material was to be burned during fire training sessions, which are held at the Old Sewage Treatment Plant site. The department decided that the burning of the resins was too objectionable and stopped the practice. The department indicated the resins would be removed and disposed of in accordance with applicable regulations.

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4.7 AQUATIC BIOTA SURVEY

A special investigation into 2,3,7,8-TCDD levels in fish from Rocky Branch and Bayou Meto was conducted. The objectives of the investigation were to:

- Document levels of 2,3,7,8-TCDD in fish from Rocky Branch and Bayou Meto, and to compare 2,3,7,8-TCDD levels in fish immediately downstream of the site with levels in fish upstream and far downstream of the site
- Provide data on 2,3,7,8-TCDD levels in edible portions of fish to assess potential endangerment to humans through consumption of fish
- Provide independent data on dioxin levels in Bayou Meto to supplement and support data previously collected by APDC&E.
- Document levels of other contaminants in fish from Rocky Branch and Bayou Meto

<u>Sample Collection</u>

Fish were collected from seven sampling stations on August 10 and 11, 1984, by CH2M HILL with the assistance of Arkansas Game and Fish Commission personnel. One sampling station was located directly downstream of the Vertac site on Rocky Branch. Rocky Breanch drains the Vertac site and the surrounding western part of Jacksonville, Arkansas. The remainder of the sampling stations were on Bayou Meto, with one station located upstream of Rocky Branch, and the other stations located downstream. Sampling station locations are illustrated on Map 4-15.

Both bottom-feeding and predatory fish were collected. The types of fish collected at each sampling station are described in Table 4-8. Fish were collected using boat-mounted electrofishing gear, hoop nets, and gill nets. At sampling stations BM02 and BM03, some of the fish were collected using Rotenone.

Some fish were filleted so that the edible portion of the fish could be submitted as a separate sample. In some cases, right-side and

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left-side fillets of the same fish were submitted separately as blind field splits as a qualitative check on laboratory analytical results. Fish samples were wrapped in aluminum foil, placed in a plastic bag, labeled, and kept on dry ice during the remainder of the day's field activities. The samples were frozen and kept frozen until laboratory analysis.

Analytical Methods

Upon receipt by the laboratory, all samples were weighed. All fish samples were analyzed for 2,3,7,8-TCDD and total TCDD content. Because previous analysis of fish by APDC&E was not 2,3,7,8-TCDD isomer-specific, the fish were analyzed for both 2,3,7,8-TCDD and total TCDD (2,3,7,8-TCDD plus all other TCDD isomers) to verify that the 2,3,7,8 isomer was the predominant TCDD found in fish in Rocky Branch and Bayou Meto. The fish were also analyzed for total pentachlorodibenzodioxin (PeCDD) through octachlorodibenzodioxin (OCDD). The analytical method used in the dioxin analysis was the "Stalling Method" (Smith, et al., 1984).

The fish were also analyzed for a variety of other potential contaminants. The fish were analyzed for the semivolatile priority pollutants and tetrachlorobenzene by the isotope dilution method (California Analytical Laboratories, Inc., Method 1625). The fish were analyzed for pesticides and PCBs by a California Analytical Laboratories, Inc., modification of a Columbia National Fisheries Research Laboratory methodology.

Results and Discussion

TCDD analytical results are summarized in Table 4-8 and in Maps 4-15 and 4-16. Map 4-15 presents the 2,3,7,8-TCDD content in whole fish samples, while Map 4-16 presents the 2,3,7,8-TCDD content in fish fillet samples. As expected, the whole fish samples had higher 2,3,7,8-TCDD contents than corresponding fillet samples. In other studies it has been shown that TCDD residues in fillets are

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approximately 50 percent of those in whole body samples (Smith and Johnson, 1985).

As can be seen in Map 4-15, the fish with the highest 2,3,7,8-TCDD levels were collected at the confluence of Rocky Branch Creek and Bayou Meto. Whole fish 2,3,7,8-TCDD concentrations approached 900 pg/g (parts per trillion; ppt), while fillet concentrations were as high as 300 ppt.

TCDD levels in fish drop off dramatically downstream of the site. Downstream of the Highway 31 sampling station (BM04;, none of the reported TCDD concentrations for fillet samples exceeded 25 ppt.

There was good agreement between the results of the 2,3,7,8-TCDD and total TCDD analysis for each sample, indicating that, as expected, the 2,3,7,8 isomer is the predominant TCDD isomer accumulating in the fish. This data suggest that the TCDD content reported in the APCD&E analytical results is comprised primarily of 2,3,7,8-TCDD.

The results of this investigation are in general agreement with earlier APDC&E work (APDC&E 1983) that showed TCDD concentrations in the hundreds of parts per trillion for fish collected immediately downstream of Rocky Branch Creek, with TCDD levels much lower in fish collected downstream of Highway 31.

Generally, 2,3,7,8-TCDD is the predominant polychlorinated dibenzodioxin found in the fish samples. Near the confluence of Rocky Branch and Bayou Meto, penta- through octachlorinated dibenzodioxins were also detected, but at concentrations less than the 2,3,7,8-TCDD levels. OCDD was found in at least one fish sample from all sampling locations except BM03. The highest OCDD concentrations (up to 6,200 ppt) were reported for samples collected farthest downstream.

There are some apparent anomalies concerning the OCDD data. OCDD is present as an impurity in some commercial pentachlorophenol (PCP) formulations, and PCP use is generally regarded as the major source of elevated OCDD levels in the environment. No PCP or pentachloroanisole

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(a PCP degradation product) was found in any of the fish samples. There were also apparent discrepancies in the OCDD concentrations reported for the blind field split samples. These samples are to be reanalyzed to confirm that elevated OCDD concentrations exist in Bayou Meto fish and to resolve the apparent discrepancies in the blind field split sample results.

A variety of potentially site-related semivolatile priority pollutants were also detected in fish collected near the confluence of Rocky Branch and Bayou Meto (see Table 4-9). These included chlorinated phenols and chlorinated benzenes. The individual contaminants were present in concentrations as high as 4,800 ppb in samples collected near the confluence of Rocky Branch and Bayou Meto, but concentrations dropped off dramatically at downstream sampling locations. Generally, elevated levels of the semivolatile priority pollutants were not found downstream of the Highway 31 sampling location (BM04). The Highway 31 sampling location was also the farthest downstream sampling location at which 2,3,7,8-TCDD levels in excess of 25 ppt (for fillet samples) were reported.

These results are consistent with the assumption used in the offsite remedial investigation that, due to its persistence in the environment, bioaccumulation potential, and toxicity, 2,3,7,8-TCDD would be the controlling contaminant. That is, if the remedial actions necessary to address 2,3,7,8-TCDD contamination are implemented, the presence of other site-related contaminants will also be addressed.

The pesticide analysis revealed the presence of a number of organochlorine pesticides and residues in the fish samples. Chlordane, at concentrations as high as 1,200 ppb, was found in fish collected in all sampling locations as far downstream as BM03. No chlordane was found in fish collected downstream of BM03.

DDT and/or DDT homologs were found in every fish sample. This was not surprising, as previous studies have shown that elevated levels of DDT and DDT homologs exist in fish in the Arkansas River drainage system (Schmitt, et al., 1985).

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Summary of Conclusions

The primary conclusions that can be drawn from the biota sampling program are:

- 2,3,7,8-TCDD makes up the vast majority of TCDD found in the fish
- 2,3,7,8-TCDD concentrations are highest in fish collected near the confluence of Bayou Meto and Rocky Branch, and decrease downstream
- Elevated levels of chlorinated phenols and benzenes are present in fish collected near the confluence of Bayou Meto and Rocky Branch, and are generally not found downstream

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5. SAMPLING AND ANALYSIS

Three RI samplings were performed, in December 1983, June 1984, and August 1984. All RI sampling activities were according to approved procedures. In addition, the August 1984 sampling was performed in accordance with an approved QA/QC plan. (See Appendix 10, Quality Assurance/Quality Control.)

Prior to the initiation of the offsite Remedial Investigation, several limited investigations had been made by various agencies, as discussed in the site history, but no comprehensive investigation of the extent of offsite contamination was conducted. Sampling protocols for the samplings previous to the RI are unknown.

Table 5-1 is a comprehensive listing of all data on dioxin and other primary pollutants in the offsite investigation area. Based on historical data on the site, primary pollutants of the Vertac site are: dioxin; 2,4-D; 2,4,5-T; 2,4,5-TP; toluene; chlorinated phenols; and chlorinated benzenes. The table includes data from the three RI samplings and the previous agency samplings, that is, the ADPC&E and EPA samplings. Most RI and previous samplings tested for dioxin. Some of the December 1983, August 1984, and previous samplings had also tested for other primary pollutants.

In Table 5-1, the samples are listed alphabetically and in number sequence, according to RI sampling code letters and numbers, and samples from the same or approximate locations are grouped in reverse chronological order. Thus, the most recent RI sample at a given location will be followed by any previous samples at or in proximity to that location, in reverse chronological order.

The letter or letters that are the first element in the RI sampling code have the following significations:

- F - Far site, that is, between W. Main Street and Bayou Meto
- FS - Far site south, that is, south of Bayou Meto

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- I - Interceptor, that is, sewer line or manholes
- N - Near site, that is, north of W. Main Street
- S - Sewage Treatment Plant

The sample numbers following the letter or letters for the December 1983 sampling are preceded by a hyphen and are normal sequential numbers (e.g., F-1...F-10). For June and August 1984, the sample numbers are three-digit numbers and they are not preceded by a hyphen (e.g., F001...F010). The specific sampling date for each sample is given in the adjacent column to the sample designation code.

After the number in the August 1984 code is a letter indicating sampling depth (the August 1984 sampling was the only one to control for depth). The letters have the following significations:

- A - 0 to 3 inches;
- B - 3 to 6 inches;
- C - 6 to 9 inches;
- E - 12 to 15 inches;
- X - Unknown, that is, sediment at an unknown depth, generally under 2 feet or more of water.

Sediments in some places consisted of a relatively loose layer over a relatively hard layer. Under these conditions, the sampling depths could not be controlled. Samples from these locations were taken from the loose top layer (considered layer A), and from the hard bottom layer (layer X).

Samples taken from the same location as a later RI sample or a proximate location, and therefore grouped with the later RI sample, are indented in the sample code column of Table 5-1. Samples taken previous to the RI do not have code numbers. They are first indicated in the sampling date column. The third column gives the map on which the particular RI sample can be found. Descriptions of RI sampling locations are given in Appendices 1, 2, and 3.

Locations of samples previous to the RI are described in the remarks column of Table 5-1. Samples previous to the RI that were not near RI

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sample locations are listed at the end of the table. Several of these samples were taken from outside the investigation area.

Table 5-2 lists other than primary pollutants tested for in the December 1983 sampling. Table 5-3 lists other than primary pollutants tested for in the August 1984 sampling.

Tables 5-2 and 5-3 include various individual chlorinated phenols and chlorinated benzenes. Some of the sampling previous to the RI tested for chlorinated phenols and chlorinated benzenes, though as totals rather than individually. These data are given in Table 5-1.

In addition to the measured values, the tables provide analytical results reported as "detection limit," and "estimated maximum concentration," and prior to 1984 as "quantification limit." The definitions of these terms are as follows:

"Detection Limit," more accurately called the "Method Detection Limit," is defined as the minimum concentration of a substance that can be identified, measured, and reported, with 99% confidence that the analyte concentration is greater than zero. The detection limit is determined from analysis of a sample in a given matrix containing the target analyte. The detection limit may vary as a function of sample type and size. Detection limits for samples are normally calculated based on instrument signal to noise ratios for the particular sample undergoing analysis.

"Estimated Maximum Concentration" is used when accurate quantification of the analyte cannot be accomplished due to interferences in the sample. The result reported is calculated assuming that the total instrument response is due to the analyte. Thus, the actual analyte concentration is probably less than that reported.

Previous sample analysis contracts have specified "Contract Required Detection Limit," also known as "Quantification Limit." This limit is arbitarily defined in the contract at some level above the detection limit. Quantification limit is affected by sample size and sample dilution.

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Detection limits are indicated in the tables and on the maps with parentheses. Estimated maximum concentrations are indicated by brackets. Quantification limits are indicated by the symbol "<," meaning "less than."

5.1 DECEMBER 1983 SAMPLING

The December 1983 sampling included the area immediately north of the Vertac site, the area south of Vertac to Bayou Meto, including the Rocky Branch drainage area, the sewage treatment system, and in and around Indianhead Lake and North Lake, west of the investigation area (see Maps 5-1 and 5-2 for sample locations and Appendix 1 for descriptions of the locations). The purpose of the sampling was to determine the extent of contamination from dioxin, chlorophenols, chlorobenzenes, toluene, and phenoxy herbicides that may have migrated from the Vertac site to surrounding areas via direct discharge or flooding.

Periodic sampling of the sediments of Rocky Branch and Bayou Meto had been performed prior to this sampling. However, concentrations of contaminants varied. The December sampling was to resample some of these previous sample locations and extend the sampling.

Residents of the Indianhead Lake and North Lake area had expressed concern that those water bodies were contaminated, so they were both sampled. The sewage treatment system was sampled for contamination that may have entered it from past Vertac discharges. Both the collection system and the treatment system, including the oxidation ponds, the outfall ditch, and the abandoned and new Rocky Branch Interceptors, were sampled. Areas adjacent to the Vertac site were sampled to detect any contamination due to flooding and runoff. A limited area surrounding Lake DuPree was sampled to determine if there was contamination from floodwaters. Seventy-four soil and sediment samples were collected.

All soil and sediment samples collected, other than those from the sewage system and Indianhead Lake and North Lake were from depths of 0 to 6 inches and were extracted with a stainless steel trowel. For the

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sewage system manholes, when sufficient sediment accumulation was present at the bottom, an Eckman dredge was used to collect samples. In manholes where there was little sediment, a scraper or stainless steel beaker on an extension pole was utilized. Sediment samples from the lakes were taken with a glass sampling tube. Samples were transferred directly into sample jars and all sampling tools were decontaminated prior to reuse. Sample information and characteristics were documented in the field. Every possible effort was made to start the sampling sequence at the least contaminated location on the basis of prior sampling data and proceed towards locations of progressively greater known or suspected contamination.

All samples collected in December 1983 were analyzed for dioxin, 2,4-D, 2,4,5-T, 2,4,5-TP, chlorinated benzenes, chlorinated phenols, and other organic compounds (see Tables 5-1 and 5-2).

The major contaminant of concern was dioxin. Dioxin was found in 40 of the 74 samples. It was found in the sediments of Rocky Branch and Bayou Meto in concentrations greater than 1 ppb. A concentration of 33.9 ppb was found in manhole 71. This manhole had been tested in 1979, when 0.159 ppb dioxin was found, and in 1981, when 10.9 ppb dioxin was found. It was found in other manholes in concentrations as high as 18.4 ppb. In the oxidation ponds of the sewage treatment plant, the concentration was as high as 2.52 ppb.

Sediment samples taken around Indianhead Lake and North Lake showed no significant contamination. No dioxin was detected. The detection limit varied between .005 and .015 ppb.

5.2 JUNE 1984 SAMPLING

An exploratory sampling of areas south of Bayou Meto was performed in June 1984 (see Map 5-3 for sample locations and Appendix 2 for descriptions of the locations). The area south of Bayou Meto had never been sampled previously. The purpose of the June 1984 sampling was to determine if this area was contaminated and should be included in the anticipated August 1984 sampling plan.

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The sampling was restricted to within 600 feet of Bayou Meto, in areas that on the basis of visual evidence had been frequently flooded. The Floodplain Delineation Study was not yet begun at this time.

Twenty-one soil samples were taken. Samples were taken at depths between 0 and 6 inches with a stainless steel trowel. Each sample was deposited directly into the sampling container. After each sample was taken, the trowel was decontaminated. All sample information and characteristics were documented in the field.

The 21 soil samples were analyzed for dioxin only. Results are shown in Table 5-1. A sample from a location approximately 600 feet downstream of Highway 161 showed a dioxin concentration of 0.43 ppb. No dioxin was detected in any other sample.

5.3 AUGUST 1984 SAMPLING

A comprehensive sampling was performed in August 1984 of the whole offsite investigation area. The purpose of the sampling was to verify previous results, to expand the sampling into areas that had not previously been tested, and to determine contaminant concentrations at depths (none of the previous sampling had controlled for depth). All samples were analyzed for dioxin, and samples from approximately one fourth of the locations were analyzed for 2,4-D, 2,4,5-T, toluene, chlorinated phenols, and chlorinated benzenes (see Maps 5-4 to 5-20).

With the exception of manhole 71, manholes in the laterals of the sewer collection system had not been previously sampled. The August 1984 sampling extended the sampling to this area. The manholes in the Rocky Branch north-south interceptor that had been sampled in December 1983 were also retested to verify the results of the previous sampling. Some of the manholes that had been selected for sampling were not sampled, however, because they were either inaccessible or full of water, or did not contain a sufficient volume of sediments. Soil samples were taken from overflow areas along the collection system. Some of the overflow areas were in the immediate vicinity of residential areas.

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At the Sewage Treatment Plant, the aeration basin had never been sampled. The basin is located between the interceptor line and the oxidation ponds, and previous sampling had shown contamination in both these locations. The locations were near the inlet weir, near the center of the lagoon, and near the outlet weir.

Previous sampling in the oxidation ponds had been performed by two different methods. The 1981 samples and probably also the 1979 samples had been taken from loose sediments. The 1983 samples were taken from hard bottom sediment. In the August 1984 sampling, samples were taken in both ways at each sampling location, and the number of sampling locations was increased.

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The abandoned Old Sewage Treatment Plant complex had never been sampled. Sediment samples were taken at the primary clarifiers, sludge digester, and sludge drying beds, and soil samples at the north and south ends of the former sludge collection area.

Downstream from W. Main Street, no samples had been taken in Rocky Branch except at road or railway crossings. Sediment sampling was performed at these and other locations. The new locations were selected on the basis of the visual stream survey, aerial photos, and contour maps. Two cross sections over the width of the stream were also sampled.

In the area of investigation, Bayou Meto had only been sampled at road and railway crossings. Sediment sampling locations were selected along the whole course of the bayou within the investigation area, and two cross sections were also sampled, as in Rocky Branch. Locations were selected on the basis of the visual stream survey, aerial photos, and contour maps.

Intermittent streams along Rocky Branch and Bayou Meto had never been sampled in previous sampling efforts. Soil and sediment samples were taken at various locations in intermittent stream areas, based on the visual stream survey, aerial photos, contour maps, and the floodplain maps.

Soil sampling locations were selected throughout the 2-year floodplain in areas of likely contamination, based on the floodplain maps, contour maps, aerial photos, and the visual stream survey.

Some soil samples were taken in the 5-year floodplain at points of special interest, such as where there was a high probability of contamination based on visual evidence or previous sampling data, or where other factors, such as use of an area, made it especially important to obtain data on it. Examples of such locations were the DuPree Park recreational facility, an area heavily used by the public, and rice and other crop fields south of Bayou Meto that are irrigated with Bayou Meto water. Locations of irrigation pumps were considered in the selection of the sampling locations.

Four area impoundments were sampled for sediments. Lake DuPree and the three unnamed impoundments were sampled to verify previous sampling results and extend the sampling locations. Some sampling locations were selected on the basis of the sonar survey. Two of the locations in Lake DuPree were selected to resurvey the ETC sampling locations which yielded the highest and lowest concentrations.

Two water samples were also taken in Rocky Branch near the end of Braden Lane to determine if water from the cooling pond on the Vertac site that had recently been released into Rocky Branch as a part of onsite remedial work was contaminating the watercourse.

A total of 258 soil and sediment samples were collected for dioxin analysis. Of these, 225 were field samples and 29 were background samples, bottle blanks, or rinsate blanks. In addition, four of the field samples were designated as laboratory replicates. The samples were sent in 10 batches of 24, and one batch of 18, to eight different contract laboratories for analysis. The following is a breakdown of the dioxin samples:

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Batch No.	No. of Field Samples	Special Samples				Total No. of Samples
		Replicate	Background	Bottle Blanks	Rinsate Blanks	
01	21		1	1	1	24
02	21		1	1	1	24
03	22		1		1	24
04	22		1	1		24
05	22	(1)	1		1	24
06	21		1	1	1	24
07	22	(1)	1		1	24
08	22		1		1	24
09	21	(2)	1		2	24
10	21		1		2	24
11	14		1	2	1	18
Totals	229	(4)	11	6	12	258

Of the 258 samples, 54 were tested for 2,4-D and 2,4,5-T. Fifty-five of the 258 were submitted to VOA analysis, acid/base neutral analysis, and pesticide/PCB analysis. Of the 229 field samples, 225 were tested for dioxin.

Background samples were soils extracted from a clean area approximately 3 miles north and upgradient of the area of investigation. At the end of the sampling day, according to the sampling plan, all sampling equipment was once again decontaminated and rinsed with acetone, and a sample of the rinsate was collected. The rinsate samples and background samples were to be analyzed for dioxin. One glass jar or one set of jars, as appropriate, from each lot of sample containers was submitted as a bottle blank for quality control. Also according to the sampling plan, the jars sent as bottle blanks were partially filled with acetone. However, due to the presence of the acetone, neither the rinsate blanks nor the bottle blanks could be analyzed.

Samples were collected according to standard procedures as outlined in the sampling plan. Clean and decontaminated equipment was used for each sample. Soil samples were taken at A, B, and C depths. In order to prevent cross contamination between samples from different depths, the sampling hole was cleaned to the bottom of the level being sampled

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with the sampling tool used for that level. Then a new, that is, clean and decontaminated, sampling tool was used for the next depth.

Sediment samples were basically of two types: loose top sediment, and hard bottom sediment. Loose top sediment samples were collected in two different ways, depending on the depth of the water. For water less then 5-foot deep, a pole with a glass or stainless steel beaker attached to the end was used. In water more than 5-foot deep, an Eckman dredge was used to collect the loose sediment samples.

The hard bottom sediment required a more elaborate technique. A 1-inch inside diameter stainless steel tube was jammed perpendicularly into the sediment and pushed with a downward twisting force. After the tube had entered a sufficient depth of sediment, it was pulled up. The sediment, especially if it was clayey, usually plugged the end of the tube. Loose sediment or water on top of the hard sediment in the tube was poured out by tipping the tube. A push-rod was then inserted at the open end of the tube and the hard sediment pushed out into the sampling jar. The process was repeated until the necessary sample quantity was obtained. For hard bottom sediments in water deeper than 5-foot, it was difficult to control the sampling locations because of movement of the boat and difficulty seeing the bottom.

Where sufficient sediment was present in manholes, it was collected with an Eckman dredge. In manholes with little sediment, a scraper or stainless steel beaker on a extension pole was used.

Estimated or measured soil or sediment thickness and characteristics, sampling depths, and water depths were recorded at each sampling location.

Of the 225 field samples tested for dioxin, 79 contained measurable concentrations; 150 were reported either as detection limits or estimated maximum concentrations. The measured dioxin concentrations ranged from a fraction of 1 ppb to >200 ppb. The highest 2,4-D concentration (290 ppb) outside the sewage system was found at the sewage system outfall into Bayou Meto. In the sewage system, the highest

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2,4-D concentration was 20,000 ppm (2.0×10^7 ppb). This was at the same manhole as the >200 ppb dioxin concentration. Of the 54 samples analyzed for 2,4-D, 16 had concentrations ranging from 10 ppb to 240 ppm (2.4×10^5 ppb). The pattern of 2,4,5-T concentrations closely followed the pattern of 2,4-D concentrations. The highest toluene concentration (49,000 ppb) was in the aeration basin. No toluene was found anywhere outside the sewage system.

The complete listing of analytical results from the August 1984 sampling can be found in Tables 5-1 and 5-3.

6. FINDINGS

The sampling data and data from the special investigations revealed a confined area of relatively heavy dioxin concentrations in the sewage treatment system, including the sewage collection system and the old and new treatment facilities. The data indicate pockets of contamination along Rocky Branch and Bayou Meto and in the floodplain, surrounded by large areas in which the sampling did not indicate the presence of dioxin. Most of the contamination was found on the frequently flooded Amy silt loam soil, which includes the stream beds of the watercourses.

The August 1984 sampling data were segregated according to dioxin concentrations in various areas and at the various depths. The areas were: Rocky Branch in-stream; Rocky Branch near-stream; Bayou Meto in-stream; Bayou Meto near-stream; north of Bayou Meto within the 2-year floodplain; north of Bayou Meto between the 2-year and 5-year floodplains; south of Bayou Meto within the 2-year floodplain; south of Bayou Meto between the 2-year and 5-year floodplains; and the sewage collection and treatment system (see Tables 6-1 to 6-9). Figures 6-1 to 6-8 show the contaminant data for the areas along the watercourses and in the floodplain plotted on graphs.

Following Figure 6-8 are two comprehensive graphs (Figures 6-9 and 6-10) of the August 1984 dioxin data for Rocky Branch and Bayou Meto, respectively.

Figures 6-11 and 6-12 are graphs of percentage of samples from August 1984 that yielded a measured quantity of dioxin along Rocky Branch and Bayou Meto, respectively.

All available data on locations along the watercourses and at manhole 71 where three or more samples had been taken at different times were used in a historical trend analysis in an attempt to determine whether contaminant migration is increasing, decreasing, or stable. Graphs of the historical trends are presented in Figures 6-13 and 6-14.

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Maps 6-1 and 6-2 show dioxin data from the August 1984 sampling for the sewage collection and treatment systems.

6.1 ROCKY BRANCH

Figure 6-9 shows dioxin distribution along Rocky Branch based on the August 1984 data. The greatest range of concentrations of samples taken at or near the same location was one and one-half orders of magnitude (at the location immediately downstream from Redmond Road). The prevalent range appears to be greater than one-half, but less than a full order of magnitude. Concentrations generally decrease from the farthest upstream location to Highway 67/167. As Rocky Branch reaches the floodplain downstream of Highway 67/167, concentrations appear to stabilize, but appear to increase again as Rocky Branch approaches Bayou Meto.

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Figure 6-1 shows a wide range of concentrations of samples at the same depth. The range is less pronounced than for samples at or near the same location, however. The range is as much as a half order of magnitude. Concentrations appear to decrease with greater depth. The highest concentrations are near the surface layer.

Data for Rocky Branch near-stream locations are listed on Table 6-2 and plotted on Figure 6-2. Since only one measured concentration was reported, it is difficult to compare these data with other data.

Figure 6-13 shows data for samples taken at or near the one location on Rocky Branch (at the Highway 67/167 crossing) that was sampled on three different occasions. However, considering the imprecise descriptions of sampling points, the number of samples is too few to indicate a historical trend.

6.2 BAYOU METO

Figure 6-10 shows a broad range of concentrations in samples taken at or near the same locations in Bayou Meto. The greatest range of concentrations is in the meandering part of the bayou, about halfway between the mouth of Rocky Branch and the railroad crossing. The prevalent range appears to be about a half order of magnitude. The most striking findings are the relatively high concentrations immediately downstream of the Sewage Treatment Plant outfall, and the apparently very slight effect of the Rocky Branch inflow.

The most contaminated area is between the Sewage Treatment Plant and Highway 161, and concentrations decrease rapidly at the downstream end of the investigation area. The variable concentrations in this part may well be attributable to scour and deposition processes. Two cross sections were sampled upstream of Highway 161. Downstream of the highway, only single samples were taken. The location 2,000 feet downstream from the highway appears to be a sediment deposit area. The rest of the points downstream appear to be scour areas.

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Data for Bayou Meto in-stream locations are listed on Table 6-3 and plotted on Figure 6-3. The figure indicates a broad range among deep bottom (level X) samples (over one order of magnitude), and a smaller range among surface (Level A) samples. Concentrations in the deep bottom sediment are greater than at the surface, possibly due to successive depositions over the years, and to the clayey character of the bottom, which would adsorb dioxin.

Data for Bayou Meto near-stream locations are listed on Table 6-4 and plotted on Figure 6-4. The figure shows a moderate range of concentrations. The range is considerably smaller than for the in-stream locations. A similarity may be observed between the corresponding in-stream and near-stream data on Rocky Branch and Bayou Meto, apparently indicating a difference in scour and deposition activity in-stream and near-stream, due to higher water velocities in-stream and lower velocities in the floodplain.

Figure 6-13 shows data for two locations along Bayou Meto where three or more samples were collected since 1979. One, at Highway 67/167, was sampled five times. The other, at Highway 161, was sampled six times. For both locations, the 1984 plotted values are averages of two measurements, although the higher measurements are more significant than the averages. It appears from the data that the 1983 sample at Highway 67/167 and the 1981 sample at Highway 161 may not have been taken at the same point as the other samples at those locations. In both cases, there is a wide variability among samples. The data show a moderately decreasing historical trend in dioxin concentrations at Highway 161, and no apparent trend at Highway 67/167.

6.3 IMPOUNDMENTS

There were no concentrations as high as 1 ppb in Lake DuPree, or the north, middle, or south unnamed impoundments. The data on Lake DuPree neither confirm nor contradict the data from the study done for Vertac by ETC (see Chapter 2 and Appendix 7).

6.4 FLOODPLAIN

Data on the floodplain are shown in the following tables and corresponding figures: Table 6-5 and Figure 6-5, north of Bayou Meto within the 2-year floodplain; Table 6-6 and Figure 6-6, north of Bayou Meto between the 2-year and 5-year floodplains; Table 6-7 and Figure 6-7, south of Bayou Meto within the 2-year floodplain; Table 6-8 and Figure 6-8, south of Bayou Meto between the 2-year and 5-year floodplains.

Of the 74 dioxin samples taken in the floodplain, only 13 yielded measured concentrations. The rest were below detection limits, which varied from 0.02 ppb to 0.9 ppb. Of the 61 samples with less than detection limits, 23 had less than 0.06 ppb; 42 had less than 0.10 ppb; 48 had less than 0.20 ppb and; 56 had less than 0.40 ppb. Of the 13 measured concentrations, only 6 were 0.5 ppb or higher, and 4 were greater than 1.0 ppb. Of the detected values, only 1 sample of the 32 taken south of Bayou Meto yielded a measured concentration, and 26 were reported as less than 0.06 ppb (detection limits). Thus, the primary potentially contaminated area of the floodplain is north of Bayou Meto.

The variable limits of detection reported by the laboratories make it impossible to quantify the lower limit of contamination other than to

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say the majority of the floodplain sampled contains low dioxin contamination, if any. It also is pointed out that the situation is not static since the sewage system and the site still potentially discharge dioxin-contaminated sediments and the existing stream and floodplain deposits will be continuously altered as a result of instream fluvial processes and flood events, respectively.

One sample exceeding 1 ppb dioxin was found in the open floodplain, and two were found within 100 feet of Rocky Branch. The sample in the open floodplain was from between Lake Dupree and Bayou Meto (1.58 ppb). The two from within 100 feet of Rocky had 1.5 and 1.7 ppb. Considering the vast expanse of the floodplain and the small number of samples collected, the existence of other deposits containing greater than 1 ppb dioxin remains a possibility. However, the data indicate that the majority of the floodplain has only low concentrations of dioxin, if any.

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Low dioxin concentrations were found in the sewage system outfall ditch. However, the ditch has a steep grade, a swift and constant flow, and a hard clay bottom. These physical properties may explain the low concentrations.

The August 1984 sampling also indicated a correlation of dioxin distribution and scour and deposition activity in the floodplain. Fuller understanding of the scour and deposition activity and more precise location of the scour and deposit areas would be necessary to more effectively locate contaminated sediments.

To provide this, extensive sampling along a grid system could be used. However, such a method would require an extremely large number of samples. Modeling the flood and recession process, supplemented with selective sampling at locations indicated by the model as potential sediment deposit areas, could be used as an alternative method to sampling on a grid system.

A "Two-Dimensional Finite-Element Surface-Water-Flow Modeling System" (FESWMS) computer modeling program could be used. An FESWMS project proposal developed by the USGS is presented in Appendix 8. The modeling would yield maps of velocity-magnitude contours for the Bayou Meto system. The FESWMS model does not have sediment transport modeling capability, however. Therefore, suspended sediment sampling at key locations of the floodplain during at least two flood events is necessary for use of the model.

An alternative to the FESWMS model that could be adapted to yield sediment distribution is the "Sediment-Contaminant Transport Model" (FETRA) and its "Particulate Contaminant Transport Submodel" (Onishi 1981). The FETRA model was used in the James River Estuary, Virginia, to simulate sediment movement and the transport of a pesticide discharged to the river during the early 1970s.

Scour and deposition is of concern as far back as 1948, when contaminants were possibly first released into the investigation area. Since man-made or natural changes have occurred in the floodplain, present-day flow conditions may not be indicative of past conditions. This could limit the utility of mathematical modeling based on present-day conditions. However, the selective sampling proposed at locations indicated by the models as potential scour and deposit areas could help compensate for this limitation. Such sampling could also serve to establish correlation of the indications of modeling and actual conditions.

6.5 SEWAGE SYSTEM

Map 6-1 shows dioxin concentrations in the sewage collection system from the August 1984 data. Map 6-2 shows concentrations in the old and new sewage treatment systems. Table 6-9 shows the August 1984 data on the sewage collection and treatment systems segregated by depth. All components of the old and new sewage systems are considered to be highly contaminated with dioxin.

In the Old Sewage Treatment System, sediments in the east primary clarifier, the digester, the sludge drying beds, and the suspected sludge collection area contained greater than 1 ppb dioxin. The

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sludge drying beds, which are presently used as vegetable gardens, contained 6.59 ppb dioxin. The two samples taken from the perimeter of the digester contained 5.30 and 12.46 ppb. The sample taken from the east primary clarifier contained 1.62 ppb dioxin. A sample taken at the midpoint of the suspected sludge collection area contained 1.19 ppb.

Dioxin concentrations in samples from the aeration basin of the New Sewage Treatment Plant were 2.08, 6.5, 16.2 and 37.9 ppb. The average is 15.7 ppb. In the oxidation ponds, the averages of the samples containing in excess of 1 ppb dioxin are: north pond, 2.8 ppb; and south pond, 1.30 ppb.

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In the sewage collection system, excluding the three highest dioxin concentrations (70.5, 119.4, >200 ppb), the average concentration is 7.93 ppb. Including the three highest concentrations, it is 21.5 ppb.

The only location other than on Rocky Branch or Bayou Meto that was sampled three times was manhole 71 in the sewage collection system. The results are plotted on Figure 6-14. The steeply increasing apparent historical trend may be misleading. While it would not be surprising to find a slight increase in dioxin over time at this location, it is likely that the data are affected by a high variability of sample media and increasing sophistication of the sampling techniques over the years.

7. CONTAMINATED VOLUMES

All sediments in the sewage system, including the sewage collection system and sediments in the old and new Sewage Treatment Plant facilities are considered contaminated.

Based on the results of the sewage collection system lamping, the estimated volume of sediments in the collection system is 47 cu yd. Based on design specifications and observations of Old Sewage Treatment Plant facilities, the estimated volume of sediment is 500 cu yd. Based on design specifications of New Sewage Treatment Plant facilities, the sonar survey data, and sediment depth observations made during the course of sampling, the estimated volume of sediments in the aeration basin and the two oxidation ponds is 214,000 cu yd.

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The August 1984 data for the various sampling depths for Rocky Branch and Bayou Meto in-stream and near stream, and for the floodplains north and south of Bayou Meto, are presented in Tables 7-1 to 7-4. Table 7-5 summarizes the data for these areas at the various sampling depths. It shows number of samples taken, number of measured concentrations, and number of measured concentrations >1 ppb. Along the watercourses and in the floodplain, 49 of the 155 samples taken during August 1984 had measured concentrations of dioxin.

The data in Tables 7-1 and 7-4 are plotted on corresponding Maps 7-1 to 7-4. It was shown in Section 6 that dioxin data from a given sampling location or a given sampling depth can vary substantially. Therefore, the reliability of the data must be considered to be within an order of magnitude.

0 To 3 Inch Level

At the surface to 3-inch depth, measured concentrations of dioxin were found in a total of 24 samples. These were in Rocky Branch between S. Redmond Road and Bayou Meto (0.27, 0.15, 0.16, 0.41, 0.22, 0.74 ppb), and in the adjacent floodplain (1.7, 0.23 ppb); in Bayou Meto at the sewage treatment plant outfall (0.74 ppb), at the Highway 67/167 crossing (0.27 ppb), in the stretch from the meandering area above the railroad crossing to the Highway 161 crossing (0.37, 0.10, 1.1, 0.54, 0.81, 0.39, 0.34, 0.25, 0.31); at one point in the floodplain just south of the meandering area of the bayou (0.9); and two points in the floodplain north of the bayou (0.86, 0.61); and in Lake DuPree (0.37, 0.11).

<u>3- To 6-Inch Level</u>

At the B level, where few samples were taken, measured concentrations were found in a total of seven samples. These were along Rocky Branch just above and below the Highway 67/167 crossing (0.39, 0.10 ppb); in the floodplain east of Rocky Branch (0.24 ppb); in Bayou Meto at the Sewage Treatment Plant outfall (1.1 ppb), and in the meandering area of the bayou (1.52, 0.78, 1.2 ppb).

<u>6 To 9-Inch Level</u>

At the C level, measured concentrations were found in a total of 11 samples. The two highest measured concentrations outside the sewage system were found in Rocky Branch between the Vertac plant and W. Main Street (7.58 ppb) and the adjacent floodplain (3.01 ppb). Another measured concentration was in an adjacent residential area, outside the floodplain (0.10 ppb). In Rocky Branch at West Main Street, a concentration of 0.14 ppb was found. In the floodplain west of Rocky Branch south of Redmond Road, a concentration of 1.5 ppb was found. In Bayou Meto a concentration of 2.1 ppb was found just below the Sewage Treatment Plant outfall; 1.3, 0.4, and 1.1 ppb were found in a cross section in the meandering part of the bayou; 1.08 ppb was found downstream of the Highway 161 crossing; and 1.58 ppb was found in the floodplain north of the meandering part of the bayou.

<u>X Level</u> (Other Depths)

At the X level and unknown depths, considered to be around 12 inches, measured concentrations were found in a total of seven samples. These included 0.12 ppb in the downstream end of Rocky Branch; 0.88 in

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Bayou Meto just upstream from the mouth of Rocky Branch; 0.10 and 0.2 ppb in the meandering part of the bayou; 1.10 ppb just upstream of Highway 161; 0.59 ppb downstream of the highway, near the west end of the area of investigation; and 0.18 in Lake DuPree.

The results of sampling along the watercourses and in the floodplain indicate the possibility of widespread low-level contamination with dioxin. The highest contamination areas, according to the data, are along Rocky Branch, especially at the upstream end; along Bayou Meto near the Sewage Treatment Plant outfall, in the meandering part of the bayou above the railroad tracks, and between the railroad tracks and Highway 161; and in the floodplain above and below the meandering part of the bayou. However, the data are insufficient to delineate contaminated areas or calculate volumes of contaminated media. To accomplish these objectives, fine-grid sampling would be necessary.

In addition, it should be considered that contaminated sediments in the watercourses may be relocated at any time or may be being continuously relocated due to normal water flow, and contaminated sediments in the floodplain may be relocated by successive floodwaters.

Meanwhile, the highly contaminated materials in the sewage treatment system are a continuing source of contamination to the watercourse and floodplain system.

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PHOTOS

Set of Aerial Photos (1969 and 1949)

Photos along Rocky Branch and Bayou Meto downstream from Vertac plant site obtained during stream survey.

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